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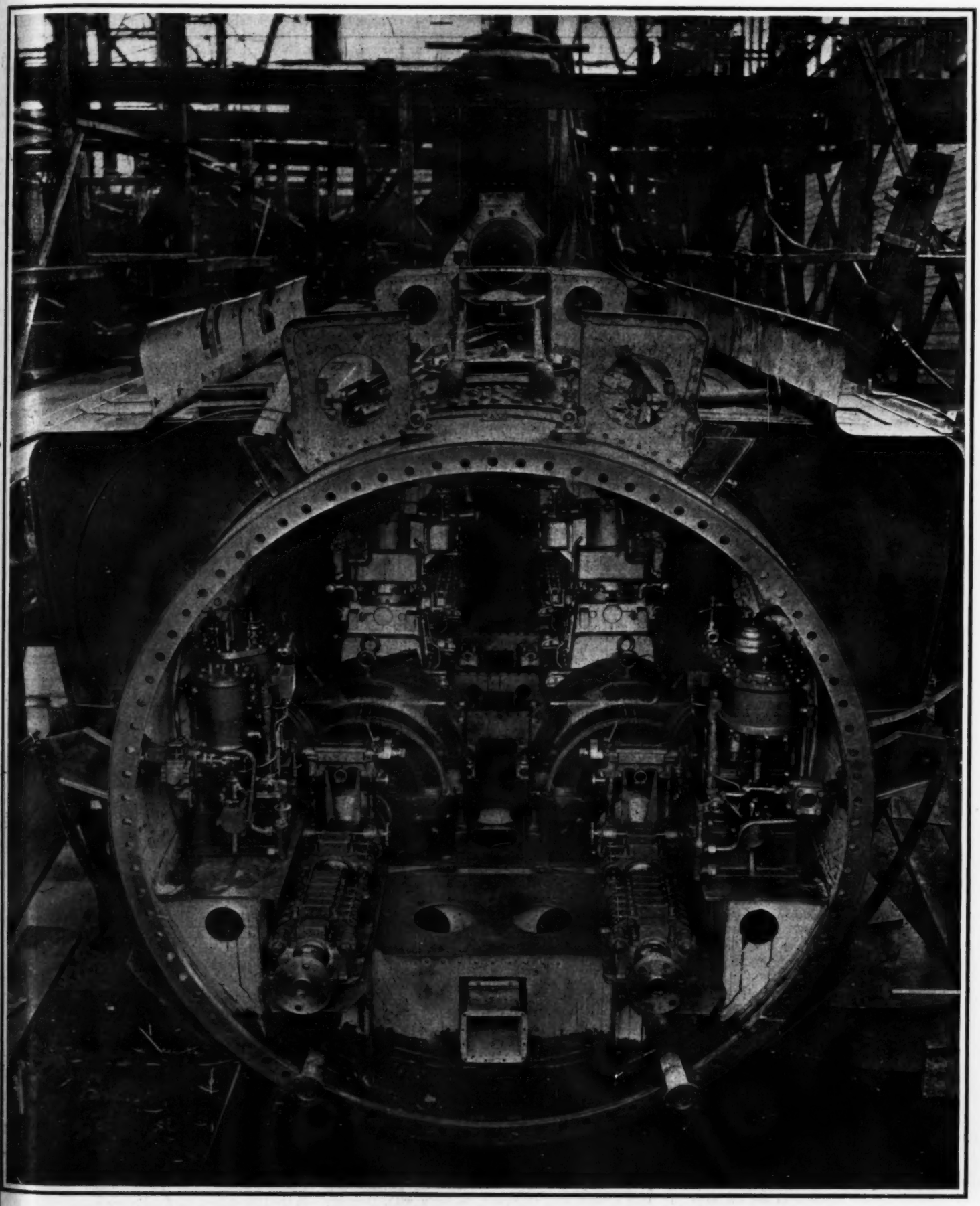


View of the interior before the rear section was bolted on. Note the thrust bearings, the electric motors, and the gasoline engines.

SECTIONAL VIEW OF A TYPICAL GERMAN SUBMARINE.—[See page 148.]

Germany as an Industrial Power

An American Manufacturer Discusses the German Inspiration and Reviews Its Commercial Growth

After a tour abroad for the purpose of observation and study of foreign commercial and industrial methods Frank A. Scott of the Warner & Swasey Company gave the results of his investigations in a comprehensive address before the Cleveland Advertising Club. His attention was particularly directed to the methods and causes that have made Germany a world-wide power in commerce, and his remarks are of particular interest at this time. The *Iron Age* published lengthy abstracts from the address, from which the following are derived.

The German empire that we now deal with, and the German empire that is going to teach us, is teaching us, many things, and that will be the most interesting subject for business men and statesmen during the next twenty-five years, dates from 1871. I want to give you a suggestion of the size of Germany as related to a number of powerful European nations, and the United States, and the conditions under which that population lives. Russia, which has the largest area of any of the European nations, has 8,555,555 square miles. Germany comes next; but note the difference—208,000 square miles. Germany has an area about equal to Indiana, Illinois, Wisconsin, and Michigan. France has 207,000 square miles, and England 121,000—that is, the British Isles. Russia has a population per square mile of about 19; the United States (and you will note that our population seems scant) has 32; France has 191, but Germany has 311. Just as soon as we know that, if we know anything about the Germans, we know we have a condition of compression which is going to grow so great that it must find relief.

And that is where the difference in policy came between Bismarck and the present Emperor. Bismarck had unified Germany. His mind rested largely on the idea of a centralized and a unified Germany; whereas the present Kaiser has seen the need for expanding the boundaries of his country, for finding places where the force and energy that have been developed by the German schoolmasters can find expression under other suns than in Germany.

GERMANY FEEDS ITS OWN PEOPLE.

Such a population as 311 per square mile presents a great problem in the feeding of the people. In most European countries where the population is so dense, the importation of food products is a necessity. England is a very marked example of that. England imports grain from a number of countries. She imports meat largely from this country and from Australia; her dairy products from Denmark, Finland, Norway, and Sweden. Germany has developed her power to feed her people within herself, and has applied the wonderful science of that country to the problem of taking care of the population within her own boundaries.

I want to give you the inspiration of the agricultural figures of Germany, that show by what means she has accomplished this. In 1881 Germany raised of wheat 1,397 pounds per hectare, about 2.47 acres; in 1913, 2,596 pounds, an increase over the same acreage of 85.8 per cent. Rye in 1881, 1,199 pounds; in 1913, 2,100 pounds—increase 75.2 per cent. Oats in 1881, 1,331 pounds; in 1913, 2,409 pounds—increase 81 per cent. Potatoes in 1881, 11,869 pounds; in 1913, 17,446 pounds—increase 47 per cent.

Perhaps we would be interested to see how these figures compare with those for the United States. During the same 30-year period our yield of wheat per acre changed from 13.1 bushels to 13.9 bushels; of rye, from 13.9 bushels to 16 bushels; of potatoes, from 91 bushels to 93.8 bushels. The corn acreage of our country has increased tremendously in the 30 years, but my recollection is that we produce just as many bushels per acre to-day as we did 30 years ago.

You gentlemen are perhaps thinking that our conditions are different; that there is no reason in the United States, or at least there has been none, for the adoption of the intensive methods of cultivation which Germany has adopted. And that is so. I want to say, after quoting the American figures, it probably has been better for us with our tremendous acreage and with the great amount of virgin soil that was available to the American farmer, to handle a vast acreage, but without such intense cultivation. In fact, with our scanty population, such intense cultivation is impossible. But the German figures are interesting to us as showing what can be done by a diligent nation on a naturally poor soil in rigorous climate.

Germany has met these agricultural problems by applying to them scientific methods in her drainage, in irrigation, and particularly in the use of commercial fertilizers. The consumption of commercial fertilizers in Germany increased from 1,600,000 metric tons in 1890 to 6,000,000 tons in the year 1910. There is an interesting thing about these commercial fertilizers. The German pig iron production has increased tremendously in these twenty years. By what is called the Thomas-Gilchrist process they were able to use high-phosphorus pig iron in steel manufacture, and the resulting slag was very rich in phosphorus. Grinding that up gave a product that they called Thomas phosphate flour; and to-day millions of tons of phosphate flour are used on the lands of Germany. So she not only increased her ability to produce steel but increased her ability to produce potatoes by using the invention of Thomas and Gilchrist.

WONDERFUL GROWTH OF TRADE.

The population of Germany about the time of the formation of the empire was 44,000,000 approximately. To-day it is 60,000,000. This immense growth in population, and particularly the crowding of the people into the cities—for in that respect Germany has had the experience of all civilized nations—has necessitated the development of industries to employ those thronging workmen. So Germany is changing as other nations are, from an agricultural to an industrial nation, but she has responded remarkably to this need.

Because my subject deals particularly with foreign trade, I am going to confine the figures of growth to a few dealing with the exportation of industrial products. The highest on Germany's list, the product in which she has advanced most, from 1883 to 1912, is machinery of all kinds. The value in 1887 of machinery exported was 52,800,000 marks; in 1912 it had risen to 630,300,000 marks. Coarse and fine iron products rose from 96,000,000 marks in 1887 to 581,000,000 marks in 1912. Coal exports from that small country rose from 79,900,000 marks in 1887 to 436,600,000 marks in 1912. Coke exports in 1887 were 9,000,000 marks; in 1912 they were 126,000,000 marks. Cotton, woolen and silk goods increased from 261,000,000 marks in 1887 to 966,000,000 marks in 1912. These figures explain to all of us who have been in countries where we seek foreign markets why we find the German there, and we do find the German there, and he is there very strongly entrenched, and he deserves it.

THE GERMAN MERCHANT EVERYWHERE.

I remember years ago, I think it was 1907, when my interest in the German was first excited. It was because in Mexico I noticed in every one of the twenty-four cities and towns visited on the trip, if you inquired for the hardware merchant or the leading man who could speak English, you were pretty sure to find he was a German. Their volume of business in Mexico, I think, is not equal to that of Great Britain as yet; I will say it again, *as yet*.

In 1887 Great Britain stood first in pig iron production, the United States second, and Germany third. To-day the United States is first, with 31,000,000 tons in 1913, Germany second, with 17,000,000 tons, and England third, with 10,000,000 tons. The total pig iron production of 1913 of the world was estimated at 75,000,000 tons, and of this Germany, with her poor ore, produced one fourth. To-day Germany ranks second in steel production, third in coal production, third on 208,000 square miles in the production of wheat and rye, and second only to the United States in the length of her railroads.

Within the period of 25 years, the percentages of increase in foreign trade of the three leading foreign export nations were as follows: United States increased 208 per cent, Germany 185 per cent, United Kingdom 119 per cent. And those are the figures with which I want to prove my point, that to-day we must look, not to our former teacher, England, for inspiration in foreign trade, but to Germany. And we shall have to work very hard, in my opinion, even with a gain of 208 per cent compared with 185, to retain our position during the next 25 years. And all of us who have an opportunity to contribute to that will have to take the subject seriously, or when we read these figures 25 years from now, Germany will be at the head and not the United States.

THE SCHOOLMASTER AND THE DRILLMASTER.

I think every student of the industrial problem in Germany will agree in the great advantage which Germany has in her military training. The influence of two things it seems to me is particularly marked in Germany—the German schoolmaster and the German drillmaster. Of course, to begin with, Germany is a Christian nation. I think that helps, and I am founding everything else on that. You know that until within a few years most of the men who grew to maturity in Germany served in the army. Now their population is increasing so rapidly that they do not have to be as severe in the selection of men. Of the total number offering they select fewer to-day than they did some years ago; but nevertheless the great bulk of the male population of Germany for a hundred years has been trained in the German army. I believe you can see in every man in that country the effect of training in habits of discipline, self-respect and honesty. In that particular Germany has a lead over both England and the United States, and this probably we will be many years in overcoming, if we ever adopt such a system.

I have read and I have heard it said that this tremendous growth of German industry and commerce constitutes a menace to American trade. Personally I do not reason that way. Opposition strengthens us. Our competitor is our helper. I would prefer to find an inspiration in what Germany has done rather than a menace. If the Germans are expanding their foreign trade at the expense of other nations, it is because they, more than any other nation, have planned their work. The question is, Did they attain this great force as a commercial and industrial nation through, for instance, great natural resources? The answer must be, No.

COMMAND OF THE SEAS.

I have shown you that Russia and the United States both have natural resources greatly in excess of Germany. Have the Germans reached their position by reason of the fact that they were able to qualify under Sir Walter Raleigh's doctrine that "whoever commands the sea commands the trade"? The answer has to be, No. Germany has never commanded the sea. It has been true up to this time at any rate, according to my reading of history, that whoever commands the sea commands the trade. When Portugal commanded the sea she commanded the foreign trade; while Holland commanded the sea she commanded the foreign trade. To-day England commands the sea, and she is the greatest export nation at this time. Germany is second in sea power, and she has never tested her naval strength with any naval competitor. It may be that the future has in store such a test, and if it comes and Germany goes to the front in that test, Germany will surely command the world trade. We will take whatever position is assigned to us at that time.

I am not speaking to-day as a jingo, but speaking only as an American business man may. I want to quote to you a paragraph from a pamphlet written by Dr. Karl Helfferich, director of the Deutsche Bank, which he wrote in celebration of the present Kaiser's twenty-fifth anniversary. This deals particularly with the relation of the German naval power to foreign business:

"German economic life is conscious of being strong enough, in times of peaceful competition, to maintain and strengthen its position. But the temptation for a strong nation to make use of its political and military resources against a weaker one in the struggle of economic competition has at all times been very great. The numerous wars over commerce in the history of the world give evidence of this. All the progress of culture and civilization in the life of the nations must not deceive us and cause us to forget that any too sharp divergence in the development of economic strength and political power creates a tendency toward a violent explosion and re-establishment of equilibrium. Knowing this, Germany, which is compelled by its geographical position and its experience in history to maintain a land army equal to all contingencies, had also to decide to protect its ever-growing and expanding economic relations over the seas by building a navy strong enough to nip in the bud any temptation, on the part of any enemy, to crush our economic competition by force. Our navy, the creation of our Emperor, is, in this sense, the keystone in the mighty system to which is due the extraordinary development of wealth in Germany, and which to-day constitutes the basis for the existence of the German people."

I give you that paragraph to think about some time when you are reading a discussion on the one battleship programme in Congress or when you have presented to you what was presented to me the other day: the idea of an agitation to do away with all appropriations for battleships and have the government contribute the amount to sustaining and educating babies in the United States! That is not a joke; there is such an organization in existence in this country.

AMERICAN AND GERMAN ADAPTABILITY.

Many American manufacturers who have good for

eign trade have treated it as most of us do our greatest blessings, as a thing to be accepted as a matter of course, without thankfulness to the giver, and to be forgotten and neglected as soon as anything nearer at hand attracted attention.

American goods for the most part have been designed and manufactured to meet the American market, and when we ship them abroad, we ship them according to American design and manufacture, and to meet American standards. So long as they meet the need of the foreigner, and so long as he is unable to supply that need from another source, in our lines, of course, he buys them from us; but as soon as he can find some one who will meet his wishes in the design and manufacture of the goods, he finds a new market.

Germany deserves first rank in her willingness to meet the wishes of the customer, in her versatility in reaching the market and in satisfying the customer, and in the interest which she shows in all the questions which pertain to the economic life and development of the customer. I am sure any one in this room who has been in the Far East or in South America, or in Mexico, or any of the countries in which German competition is now becoming very strong, will agree that in shipping facilities, in banking facilities, in social touch with the customers, Germany is rapidly becoming the leader.

Price Collier, referring to the English and not to the Americans—but it would apply almost as well to the American manufacturer as to the English—said: "The attitude, wherever you find him throughout the world, is, 'This is my way,' and it is the right way, and it is God's way, and God is the God of the English established church.'" To some degree that has been the attitude of American manufacturers in meeting their foreign customers.

FOREIGN TRADE SYSTEMS.

Germany has followed the absolutely paternalistic system in developing her foreign trade, and England has followed the individualistic system, and we have very largely followed England. We do not demand to the degree that the Germans do that the government throw the whole weight of its influence and power into the development of our foreign trade. The Germans have assisted their development by their consular system, foreign steamship lines, foreign banking systems, rebates in freight rates on government railroads, when those were necessary to enable the manufacturer to reach a foreign market. Those things we have not had, as coming from our government, except the assistance of our consular service, and most of those things we would not want from our government.

The kind of prosperity that this development has brought to Germany is material prosperity. I realize that I am dealing only with material prosperity, and that to sneer at commercial prosperity is now regarded not only as safe, but as patriotic. But this does not change the fact, nor will it ever change the fact, that commercial prosperity means work for the idle, food and shelter for the needy, hospitals for the sick, schools for the ignorant; and whatever attitude of mind we and the remainder of the American public may get into to-day on the subject of business, we will pass beyond that and realize that, while we want it conducted righteously, yet it must be conducted and it will be conducted.

It seems to me that in this uncertain and quiet time we must make our plans for the busy time that is absolutely sure to follow. Very little that is unpatriotic is being done in this country. Most of the agitation that disturbs us, and that we fear, is by men who believe they are doing what is right. We as Americans cannot believe that America has come to the end—that she will never be greater than she is to-day. We know that we will be greater and that we will be better, and that the successes of the future will be founded upon the successes of the past. And that is why at this time personally I am looking everywhere for inspiration. I believe if there is any danger in our own country, from our own acts, or to our own country by reason of the processes that are going on in other nations, the American business man and the American working man unitedly will find in any peril that menaces us only opportunity.

Aircraft on the Defensive and Offensive

FRANCE is zealously striving to adapt the flying machine to aggressive warfare. Among others, there were begun at the flying field at Buc in October, 1913, tests before a military committee with the so-called "Air Craft Hunter" of Lieut. Mailfert. The flying machine, which was already exhibited at the last Aeronautic Exhibition in Paris, is a Nieuport monoplane of 160 horse-power. It contains in its *fuselage* a shot-sieve or a projectile thrower, an arrangement which, when the pilot sets it in action, strews the underlying ground with two thousand shot. An aiming arrangement is said to be at hand. On the flying field a flying machine was represented to actual scale by means of a disk. Lieut. Mailfert rose in his machine to a height of 2,000 meters and flooded the target with his projectiles. The disk was riddled with many bullets. Then free balloons were released, against which also Mailfert brought his shot sprinkler into action. He succeeded in causing two balloons to sink.

Another kind of aggressive flying machine, the so-called "Zeppelin-Hunter," was put to trial last summer, according to the Paris *Journal*. With its own weight reduced to a minimum, it had to carry an armor of 60 to 70 kilogrammes to protect both the pilot and the more vulnerable parts of the machine. It is intended to provide the flying machine with a light machine gun, which can perforate the Zeppelin hulls with rapid fire shot and ignite the gas.

In January, 1914, an experiment took place also in Villacoublay, with a new armored flying machine, which was built and provided with a rapid-fire gun, according to the directions of the heads of military aeronautics. The ordnance, presumably a machine gun, is claimed to have signal striking capacity. The flight, however, which the pilot, Espaner, effected, with the new aeroplane, was not very fortunate.

The French papers emphasize that in future all French military air craft, except the school machines, will be armored to protect them against hostile fire. They may be divided into the following kinds:

1. Armored monoplane for reconnoitering artillery and cavalry. Minimum velocity, 120 kilometers per hour.

2. Armored biplane for reconnaissance work of the general staff at great distances. Minimum velocity, 100 kilometers per hour.

3. Armored biplane which, provided with machine guns, etc., shall destroy hostile aeroplanes and airships. Minimum velocity, 120 kilometers per hour.

4. Large aeroplanes with more seats for special service.

The Paris Aeronautic Exhibition last fall showed a special number of armored aeroplanes. The armor protection extended not only to the pilot and observer, but also to the provisions, the rudders, the measuring instruments and especially the propulsion system. The aeroplanes not intended for aggressive warfare were for the most part provided with wireless apparatus.

The improvement in the possibility of observation was shown at Villacoublay late in November, 1913, on a new kind of aeroplane in which the seat for the observer is placed forward, directly under the screw propeller. Deputy Girod, piloted by Gobé, flew over the field several times and made effective observations. The capacity for observations from this position is without doubt greater, still the observer in this advanced position is more exposed to hostile fire, and above all is incapable of taking charge of the controls of the aeroplane in case of failure of the pilot.

At Farnborough in England last year a trial of sharpshooting from aeroplanes was held. A military biplane was provided with a machine gun and ammunition; this gave, from an elevation of 120 meters, 20 shots directly downward. As to its striking capacity and effect, nothing has been reported; the recoil from the shot was without notable influence on the equipoise of the aeroplane.

Also a Birmingham society instituted at Bisley sharpshooting at an aeroplane with a machine-gun. The 26-pound, air-cooled machine-gun invented by Col. Lewis was fixed on a tripod on the aeroplane framing; on a tripod was also placed the movable seat for the protection of the aviator. Out of thirty shots at a target space of 20 feet, 11 hits were scored. From what elevation the aeroplane fired has, however, not been reported, nor the velocity of the air craft, nor the kind of target arrangement.

A sighting arrangement for machine guns on air craft has lately been patented. The machine gun is fixed between the legs of the observer sitting forward and having charge of the gun. The aviator sits elevated behind the observer. The forepart of the aeroplane is covered with a hood which carries on top a notch and sight. When the target is in sight the observer calls to the pilot and adjusts the sighting arrangement for distance and altitude. The aviator directs the aeroplane at the target by use of the rudders in conjunction with the notch and sight. When the observer perceives that the direction coincides he promptly fires.

An aeroplane projectile with rear rudder has been made in England. A tube extends lengthwise through the middle of the cylindrical projectile, filled with explosive. It carries, in front, trigger pins and percussion caps separated by an interspace, and having well to the rear an ignition charge. Both parts are secured by bolts fixed to the aeroplane frame, and, through the projectile, interlock in the tube, and so protect the aeroplane from destruction by its own discharge due to hard landing, shocks, etc. The part of the tube extending to the rear of the projectile carries the tail rudder. The projectiles hang on two hooks perpendicular to the floor of the aeroplane frame. When the projectile is to be thrown, the aviator establishes a special relation between the measured altitude and the velocity of flight, aims at the target, and, by means of a hand lever, releases the supporting arrangement of the projectile. The projectile, now free, sets itself point downward by means of its tail rudder. Since the two safety bolts have remained behind in the aeroplane, the igniter is in working condition, and when the projectile strikes, the trigger pin pierces the percussion cap, ignites the ignition charge, and this sets off the explosive charge of the projectile.

Shooting at aeroplanes was carried on last year in the camp at Chalons. A kite seven meters in width by six meters in length, represented an aeroplane and was towed by an automobile and wire cable with a velocity of 60 kilometers per hour. It was fired at by two squads of infantry of fifty men each, at a distance of 800 to 900 meters. Out of nine hundred shots (nine cartridges for each man) twelve hits were scored on the kite, that is 0.12 for each man. A second shooting, with the same number of men, at a small kite, measuring 1.5 meters broad by 1 meter long, gave 0.5 shot per man, but at a distance not reported. Machine guns were trained against the same target, but with less effect.

A Spanish aeroplane was hit last November by Moroccans. Capt. Barreiro and Lieut. Gil-Rios undertook, in a reconnaissance on a military biplane, to observe the position of the insurgents. In this they were subject to fire by a group of hostile troops which had got footing on Conical Mountain. The lieutenant was grievously injured by two shots, the captain was wounded by one shot. It was possible for the officers, in spite of their wounds, to fly back again to their own camp—a proof, therefore, that even effective fire does not always put an aeroplane out of commission, and that an energetic aviator, even in spite of his wounds, will often carry out his orders.

[Translated for the SCIENTIFIC AMERICAN from *Kriegstechnische Zeitschrift*.]

New Arrangement of Mirrors for Lighthouses, Etc.

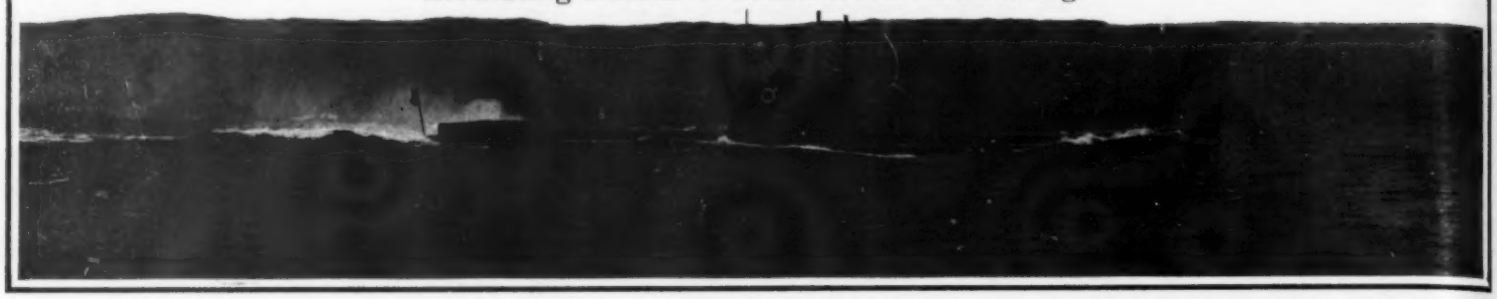
E. CANNEVEL describes a new arrangement of mirrors for lighthouses in *Comptes Rendus* that greatly increases the reflecting surface. This arrangement consists of a stepped mirror, which is composed of a number of parabolic and annular elements, and is combined with a spherical mirror. The different paraboloidal fragments all have the same focus, and part of each projects rays directly to infinity, while the other part, masked by the succeeding step, also sends the rays to infinity, but by way of the ring connecting them, the angle of incidence making the rays pass through the spherical mirror placed at the bottom of the truncated, circular stepped mirror. This arrangement of mirrors increases considerably the reflecting surface and, since the images projected by the rings are not exactly superposed, it may be used with filament lamps. Difficulty having been experienced in making the mirror in metal, use is made of glass silvered electrically by kathodic projection under a bell, which, after being evacuated, was filled with hydrogen under pressure in order to prevent oxidation of the metal.

Oscillating Spark as an Economic Source of Ultra-Violet Light

EXPERIMENTS have been made with a view to obtaining the most suitable conditions for the production of ultra-violet light from the spark of an oscillatory circuit, and, in particular, of the "mean ultra-violet rays" used in sterilization and photochemical reactions. It is found, says J. de Kowalski in *Comptes Rendus*, that the region of max. radiated energy is displaced toward the longer wave-lengths as the current in the oscillatory circuit is increased, but toward the shorter wave-lengths the greater the amount of energy consumed in the spark; its position and intensity varies also with the nature of the electrodes. The intensity of the "mean ultra-violet rays" increases as the frequency of the oscillations decreases. If a resonance transformer is used as the source of the oscillations a definite relation can be obtained between the number of sparks per sec., the capacity, and the frequency of the primary current, and thus the most economic conditions of working can be obtained.

German Submarine Boats

Interesting Details of Construction and Fittings



A Krupp submarine running at 12 knots on the surface.

THE submarines of the "Germania" type, evolved and developed by Krupp, are the standard class of submarine in the Imperial German navy. The Krupp firm have always considered the "diving" boat to be the most efficient form of submarine, and it may be mentioned that their contentions as to its all round superiority are upheld by the German government naval authorities.

A typical Krupp submarine measures 120 feet in length, with a beam of 12 feet 2½ inches, and a draught of 12 feet 5 inches. The displacement on the surface is 225½ tons, and when submerged 280½ tons. The vessel is provided with two hulls. The outer has the lines of a torpedo boat, which with the high freeboard and superstructure serve to render the boat extremely seaworthy. The inner hull is divided into three longitudinal sections, being built up of three circular welded sections bolted together. This shell is of sufficient strength to enable the craft to withstand safely a water pressure equivalent to a sea depth of 295¼ feet. The space between the outer and inner hulls is subdivided into a number of watertight compartments, which contribute greatly to the safety of the vessel, since a number of these may be punctured without endangering floatability. The water ballast, oil, and gasoline tanks are also carried in this space.

The engine room, containing the propelling and auxiliary machinery, is placed aft, together with a portion of the accumulator battery. Surface propulsion is effected by two sets of four-cylinder, vertical, gasoline motors, developing an aggregate of 440 horse-power, while when traveling submerged two electric motors developing an aggregate of 250 horse-power are brought into service. The capacity of the secondary battery is 590 kilowatt hours. Forward of the engine room are the internal water ballast tanks, and amidships the conning towers in which are placed all the devices for steering, diving, and controlling the boat. The conning tower, built up of light plating has a ship-shaped form, for the purpose of minimizing resistance when the craft is traveling submerged. In the bow are the second section of the electrical accumulators and the torpedo tube room and gear. There are two torpedo tubes carried in the bow, while on the deck, aft, mounted on a bridge, is a third tube.

The diving rudders are mounted in pairs, one on either side, fore and aft, with an ordinary vertical rudder at the stern for lateral steering. Each motor set drives a reversible propeller. The accommodation for the navigating officers is in the conning tower, while the quarters of the crew of ten men are in the bow, as is also the galley.

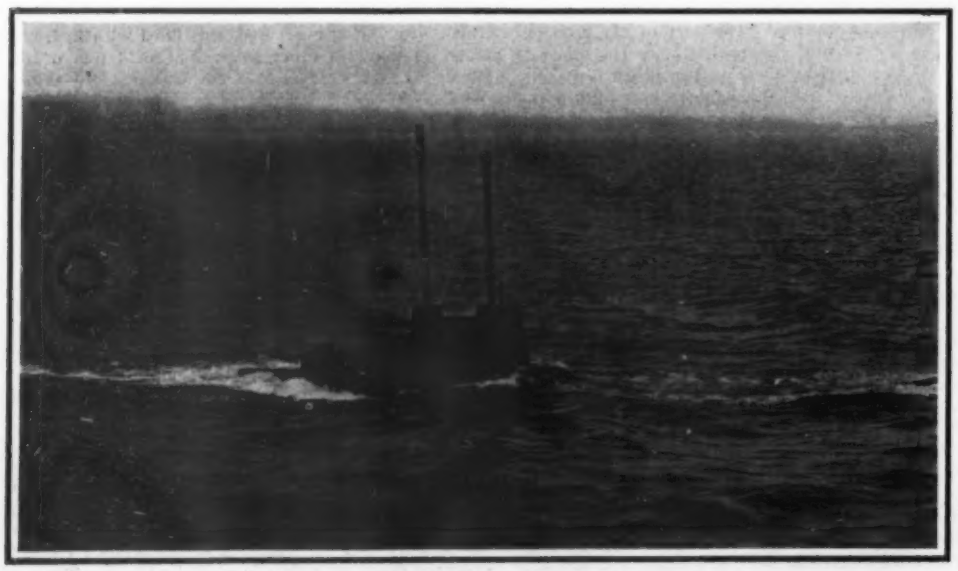
In the Lake types of the Germania class of submersibles, Diesel engines, using heavy oil in preference to the more volatile and inflammable gasoline, are used. These motors develop from 200 to 220 horse-power. For underwater navigation the usual electric motors are utilized. The heavier oil engines are useful in those seas where the lighter fuel is unobtainable. When gasoline is used, as in some types, the radius of action on the surface at the reduced speed of nine knots is 1,450 miles, while submerged it is 45 miles at the speed of 6.5 knots per hour.

Krupp submersible boat running on the surface.

Special arrangements have been made to secure an adequate ventilation of the interiors of the boats. During surface operations the air is drawn in from outside. When traveling submerged, the heated atmosphere of the engine, and the exhaled air of the crew, is drawn off through ventilators which pass it through various filtering, oxygenating and cooling devices, after which it is returned to the interior. By this means it is possible for the craft to remain under water for twenty-four hours at a time without the crew experiencing any inconvenience or difficulty in breathing. The electric accumulator compartments are hermetically sealed so as to prevent escape of poisonous gases into the interior, and to prevent the spilling of the contents through the rolling and pitching of the boat when diving. Two periscopes are carried, the tubes of which are each 16½ feet in length, which permits the craft to be navigated at a depth where it is secure from the fire of projectiles of an enemy.

Various safety appliances are fitted to prevent the vessel being placed *hors de combat* either by hostile fire or accident. The water ballast tanks can be emptied of water and charged with compressed air very rapidly, there being a reservoir of 123½ cubic feet capacity constantly maintained under high pressure for this purpose. In order to facilitate the salving of the vessel, the outer hull is furnished with a number of shackles, to which the hawsers of the salvaging appliances can be attached for raising the craft.

A telephone wire is also carried whereby communication with the interior of the submarine from the surface can be maintained. The outer end of this line is attached to a buoy which can be released automatically.



The boat awash, with conning tower partially submerged.

Variation of the Size of Drops

WHEN a drop is detached from a capillary orifice, the perimeter of the section of rupture is considerably less than that of the orifice, and the surface tension calculated according to Tate's law is much too small. It is usually assumed that the weight of the drops is independent of their frequency, whereas actually this weight shows a continual variation, which may exceed a quarter of the total weight. The results of the author's measurements show that the weight of the drop is at first sensibly constant and that it begins to increase as soon as the frequency surpasses 15 per minute. The increase is initially rapid, but later proceeds more slowly until at a frequency of 100 the weight passes through a maximum. As the frequency increases continuously, the weight of the drop exhibits three further maxima, each greater than the preceding, and subsequently appears to diminish continuously. It is evident that, when the increased frequency causes the diminution of the volume of the drop to exceed a certain limit, the drop assumes a different form, passage from one form to the other being in general sudden.—P. Vaillant in *Comptes Rendus*.

Artillery for Airship Attack

Special Designs for Guns, Mountings, and Projectiles, to Meet New Conditions

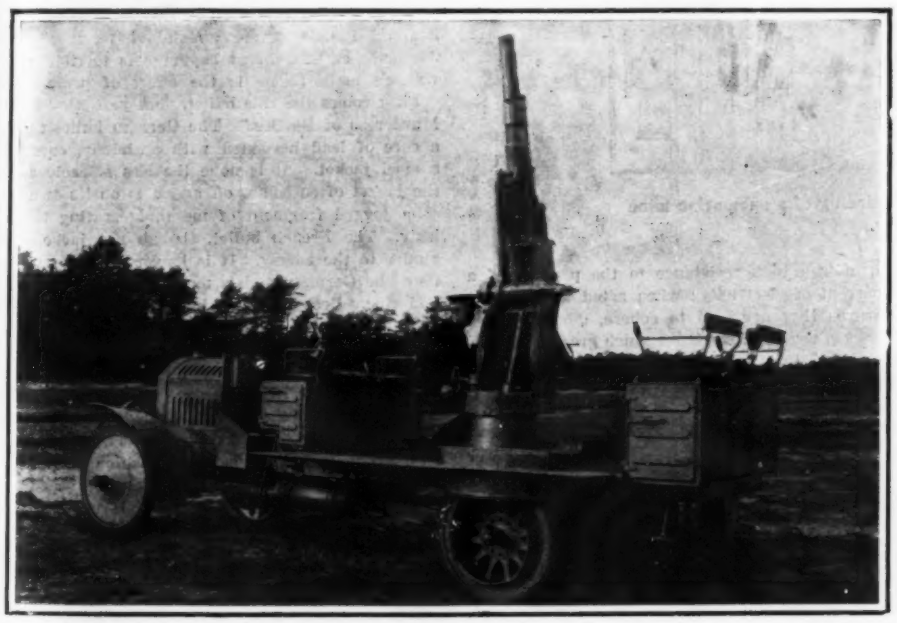
After having studied the problem which is presented by the conditions of firing at objects at great heights and at an angle such as is required for use against airships, aeroplanes, or balloons, the Krupp firm has brought out three general types of cannon, each of which is adapted for a special use. In the first place we have the more simple type of cannon with field mounting, while a second type is constructed with a view of being placed upon a motor car. For use on shipboard they design a third type, illustrated in our engraving. In the second and third cases, the cannon is designed to be rapidly rotated in all directions by the use of a central pivot base such as is usually installed on vessels and for coast defense use. On the other hand, the field gun has its wheels arranged so as to turn upon pivots, which allows of placing the wheels in the crosswise direction in the position here shown. In order to give effective results it is found that the angle of elevation must be at least 70 degrees, and the field gun is designed to reach this angle. The automobile and ship cannon will, however, make a greater angle, the maximum being for these two types as high as 75 degrees. In all these cases a rapid rate of firing is given by an automatic opening and closing of the breech. The caliber has been reduced as much as possible, as also the weight of the projectile, while the long bore gives a high initial speed to the shot and diminishes the time required to attain the mark. Owing to the lessening of the caliber, greater lightness is obtained, and this is a much to be desired advantage, especially in the field and the automobile types of gun.

Sighting is carried out in the most efficient manner by the use of an appropriate form of sighting telescope in combination with a general finder which covers a wider range of field. There is also a range-finder by which the distance is first obtained, and afterward the indications are directly given so as to be able to point the gun for different heights of the airship without loss of time, and thus the use of firing tables is dispensed with in all these cases.

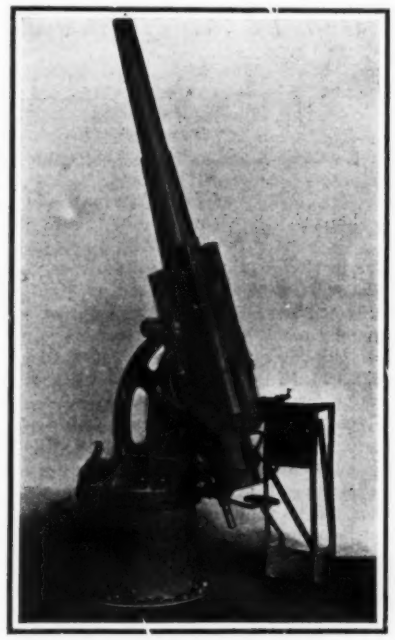
The question of the kind of shot which is best adapted for firing upon balloons or airship is of prime importance; and this matter has been made the object of a number of experiments. It is recognized that shrapnel will penetrate the balloon envelope, but without doing much damage at least of an immediate nature, seeing that the holes are closed again for the most part by the internal pressure of the gas, so that the loss of gas is not a rapid one, and the airship is able to reach a place of safety in the majority of cases. It is found that the most effective form of projectile is a special kind of grenade, which is designed to explode in the interior of the balloon and to bring about ignition of the gas. The new projectile designed by the Krupp firm is intended to accomplish this, and at the same time the path of the projectile from the time it leaves the gun can be followed by the use of a special smoke producer carried on the shot. By observing the trail of smoke the gunner learns whether the shot comes near the mark. When the projectile leaves the gun, the smoke producer has been set working by an appropriate device. At night the path of the shot is still followed by the light which the smoke producer gives out. When it penetrates the envelope a very sensitive device causes the detonation of the grenade.

In the case of the field cannon, which has a 6.5 centimeter bore (2.6 inches), the weight of the gun itself is 775 pounds and that of the chassis 1,150 pounds, making a total of 1,925 pounds for the cannon when prepared for actual service. The gun can be turned about through a complete circle, and has a maximum vertical angle of 70 degrees. The weight of the projectile for this type is 9 pounds. The initial speed of the shot is 2,050 feet per second. With the field gun it is possible to cover a maximum range of 28,550 feet, and a maximum height of 18,800 feet.

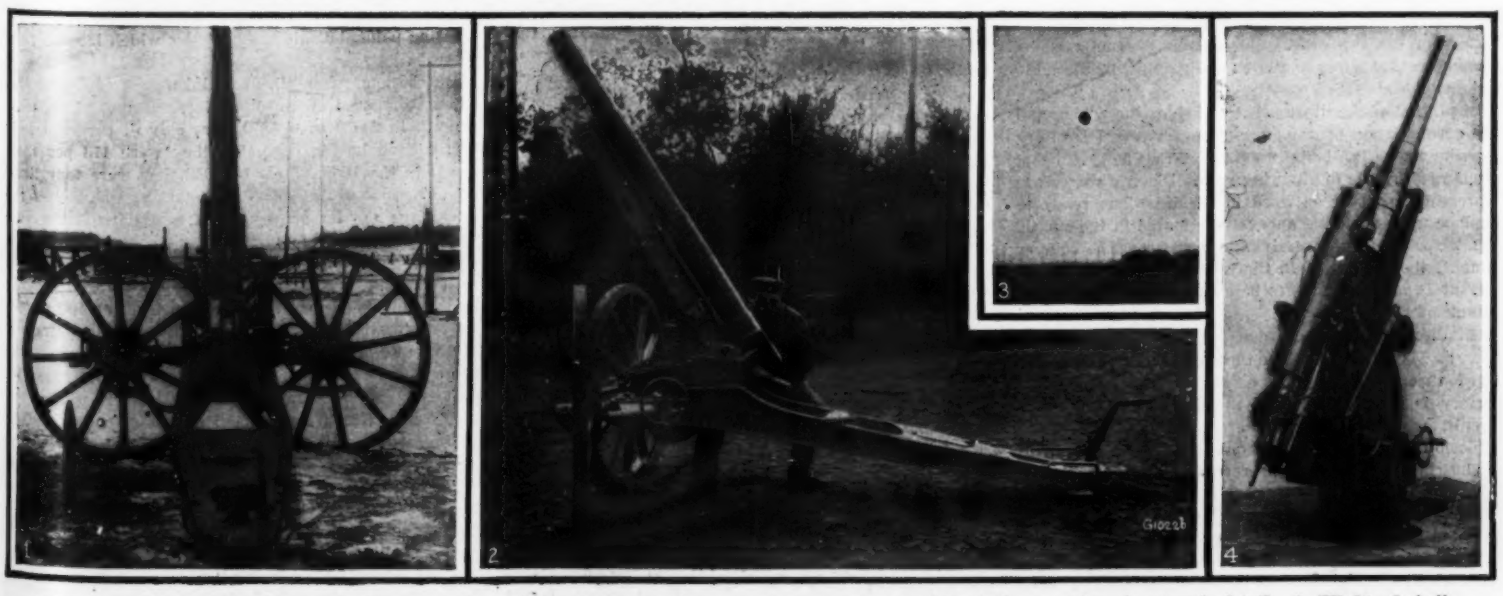
Of a heavier build than the former and also of greater range, is the second type of gun of 7.5 centimeter (3 inch) caliber, which is designed to be mounted upon a heavy motor car, as we represent it in our engraving. Like the former, it is provided with hydraulic recoil brake, and in the present case there is used a middle pivot. For elevating and lowering the gun through the required range there is used a double-toothed sector which is driven by pinion and crank. A special arrangement is used for the rotation, by which a slow movement is obtained, but a quick rotation may also be given by a more rapid mechanism when it is needed to turn the gun rapidly into any desired position. It is to be noted that, owing



The 3-inch 12-pounder Krupp field piece for airship attack. The weapon can be brought to a maximum elevation of 75 degrees. The motor car on which it is mounted is of 50 horse-power and has an average speed of 30 miles an hour.



The 4.2-inch Krupp gun for aeronautic attack, on a naval mount.



1. Nine-pounder gun in battery. It fires a smoking shell. 2. Gun carriage may be swung in complete circle around a pin at end of tail. 3. Flight of shell marked by streak of smoke. 4. Twelve-pounder for ships and fortifications.

to the high speed at which the airships move, such quick movements are one of the features which need to be especially designed in the case of guns for balloon firing. The weight of the gun itself, or 990 pounds, combined with the weight of the support, 1,550 pounds, gives a total weight of 2,540 pounds for this type of gun. We have here the maximum angle which is reached in the Krupp cannon, or 75 degrees. The weight of the projectile is 12 pounds, and the initial speed 2,060 feet per second. The maximum range is about 30,000 feet, and the greatest height about 20,000 feet. As regards the automobile car which is designed to take the present cannon, its total weight (exclusive of the gun) is 3½ tons, and it has an average speed of 30 miles an hour.

Owing to the fact that both axles are driving axles, with the use of 50 horse-power motor the automobile car is able to travel over very difficult ground, and it easily mounts very steep grades. Under the front seat is a roomy chest which holds a good supply of tools and extra fittings, and special attention has been given to this point so that the car will not easily become disabled. To make the platform of the car as steady as possible during the firing, the platform is clamped tight against the axles. The third type of cannon is of a much heavier build than the two which precede, seeing that in this case it is designed to be mounted on shipboard, and hence the weight does not need to be reduced as in the other cases. It is of a considerably larger caliber, this being 10.5 centimeters (4.2 inches). In most of the details it is designed on the same lines as the second type. It is intended to be mounted generally upon torpedo boats or swift cruisers and naturally the gun can be brought into service as an ordinary cannon in cases where it is needed. For the gun proper, the weight is 3,080 pounds, while the support weighs 3,520 pounds, giving a total weight of 6,600 pounds for this type. Like the former, the angle of elevation is 75 degrees at a maximum. The projectile, weighing 40 pounds, has an initial speed of 2,300 feet per second. A horizontal range of 44,500 feet is reached, and we have the unusual height of 37,620 feet.

The present types of gun have been given a series of tests by firing upon captive balloons, and while the practice on these may be considered fairly satisfactory, it cannot be considered as anything more than experimental, and the results are only applicable to the particular conditions of the experiment.

In actual warfare the captive balloon would seldom require consideration, and the real value of these new classes of ordinance lies in their effectiveness against big airships provided with guns and bombs and the fast aeroplanes of the scout or bomb-dropper, and for this work results with the new guns are yet to be shown.

Exploding Mines by Wireless Telegraphy

By Dr. Charles Forbes, Columbia University, N. Y.

THE newspaper accounts that have appeared from time to time in regard to the explosion of submarine mines by means of radio-telegraphy might lead the ordinary reader to believe there is danger of exploding powder magazines on war vessels, and torpedoes and mines located in harbors for defense, in the daily use of the wireless telegraph. Such an event cannot, however, take place without the intervention of apparatus specially constructed for the purpose.

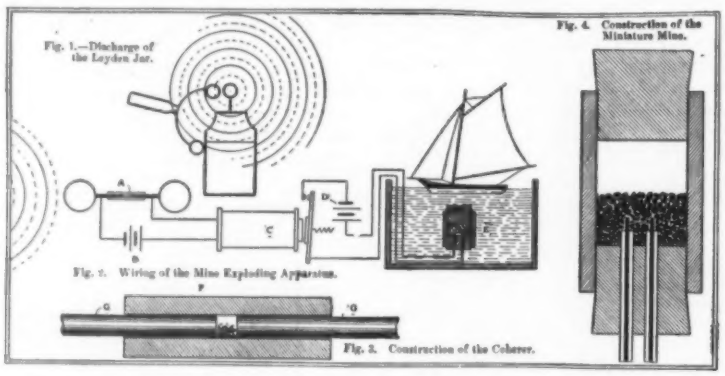


Fig. 1.—Discharge of the Leyden Jar.
Fig. 4. Construction of the Miniature Mine.
Fig. 2. Wiring of the Mine Exploding Apparatus.
Fig. 3. Construction of the Coherer.

Experimental apparatus used to illustrate the exploding of a submarine mine by wireless telegraphy.

An interesting laboratory experiment illustrative of the subject may be performed as follows: There must be apparatus for generating the electric waves, known as the Hertzian, from their discoverer; also apparatus for receiving the impressions produced by them. Like the telegraph and telephone the transmitting and the receiving instruments are essential. For the laboratory experiment the transmitting apparatus may consist of the usual amateur outfit. In the absence of this the sparks from an influence electrical machine, the induction coil or the Leyden jar will be sufficient to set up the Hertzian waves. In the simplest form the Leyden jar answers the purpose very well. The receiving apparatus consists of the Branly coherer, which is placed in series with a suitable electric battery, two dry cells being sufficient, and a relay, which in action closes a second electric circuit generated by another battery of two dry cells. This current is conducted by communicating wires to the exploding fuse in the mine to be exploded.

Inspection of the illustration will show the wiring and the arrangement of the apparatus for the laboratory experiment. Fig. 1 represents the Leyden jar being discharged by the discharging rods. Electric waves are represented passing outward in all directions ready to impinge upon receiving apparatus situated in their path. Fig. 2 represents the receiving apparatus. The coherer is at *A*, the battery at *B*, the relay at *C*, the relay battery at *D*, and the mine to be exploded at *E*, resting in a tank of water.

On discharging the Leyden jar, this is what takes place: The electric waves thereby generated pass onward through space, and acting on the coherer, its battery is set in operation, thereby closing the relay circuit, which in turn actuates the fuse, when the explosion of the mine is effected.

The essential part of the receiving apparatus is the coherer. The details of its construction are represented in Fig. 3. A glass tube about 2 inches in length is represented at *F*. Into this there are fitted, rather snugly, brass or copper rods *G*; the internal ends being separated about one eighth of an inch and the external ends having metal disks attached, somewhat larger than those represented in Fig. 2. The space between the internal ends of the rods is to be nearly filled with filings of nickel about 9 parts and silver 1 part. If the pure metals are not available for the filings nickel and silver coins may be substituted. A trace of mercury, which is desirable, may be secured by amalgamating the internal ends of the rods in the glass tube. The coherer has this peculiar property: the filings, in the inactive condition, offer a high resistance to the passage of a battery current of electricity; when acted upon by the electric waves they are said to cohere, offering much less resistance, thereby allowing a much greater electric current to pass. This is sufficient to actuate the relay.

The miniature mine to be exploded is represented in Fig. 4, about the actual size. It consists of a metal tube with a rubber stopper inserted at its upper end and another at the lower end. Through the lower stopper the insulated conducting wires from the relay battery pass. The terminals are connected by a fine iron or platinum wire, which is imbedded in the gun powder in the inclosed chamber. The fine wire on becoming incandescent ignites the powder and the explosion takes place. Interest will be added to the experiment if, preceding the explosion of the miniature mine, the closure of the relay current be made to ring an electric door bell, and if by tapping the coherer, the ringing may be discontinued. In a similar manner electric lights may be lighted on substituting the electric light current for the relay battery current. In actual practice the sending apparatus of the wireless telegraph would be used to set the ether waves in motion and the submarine mine would be attached directly or indirectly to the receiving apparatus. From the above described experiment, it is quite evident that the accidental explosion of mines and other magazines of explosives by means of the Hertzian waves is very improbable. An explosion by electrical induction would be a very different thing, and could only take place at a distance of a few feet. For its occurrence, specially arranged apparatus would also be necessary.

The Other Side of War

BY this caption Dr. E. Helme, writing in *Le Temps*, means to indicate the rougher side with which those individuals come into painful contact who feel within their own skins the effects of modern weapons. To the question: Will war be more murderous in the future? this expert answers with an unhesitating affirmative. Wars, it is true, instead of lasting a hundred, thirty, or seven years, as in bygone days, now last only a few months. But this, he says, simply means that the blows are heavier, and the combatants are sooner exhausted. The Russo-Japanese war lasted only eighteen months, but the battle of Sha Ho, in Manchuria, consumed twelve days. Thus, although the number of killed and wounded per day in the actual fighting of the Franco-German war may have been greater, the losses in battle in the Manchurian campaign were much greater in the aggregate. The truly terrible fact, however, is the increasing proportion of mortal to non-mortal wounds: In the Franco-German war of 1870-71, the victorious army lost ten men killed to every 58 wounded; in 1904-05 there were ten Japanese killed to every 37 wounded.

Coming to the explanation of these facts, Dr. Helme dismisses as "a troublesome legend" the story that modern bullets, being smaller and moving more rapidly, inflict less serious wounds. Really slight wounds, he maintains, heal more quickly and more thoroughly nowadays than formerly; but the severe wounds are no less severe and much more frequent. To illustrate this the writer considers, first, the form and structure of projectiles and then their motions. "The lance well *handled* inflicts severe abdominal wounds," and the Japanese cut-and-thrust bayonet "is terrible"; but the writer's main theme is the effect of projectiles.

First comes the rifle bullet, "but yesterday the Queen Murderess of Battles." The German bullet consists of a core of lead hardened with antimony, covered with a steel jacket. It is none the less efficacious because the jacket often comes off and acts on its own account as a jagged fragment of metal, lacerating the human body. The French bullet, though not jacketed, is no kinder to the enemy. It is longer and sharper-pointed than the German, and is made of a mixture of copper and zinc. Becoming bent by ricochetting, it sometimes enters its victim's body in the shape of a hook; sometimes it "tumbles" in its flight, enters broadside-on, and makes a long, gaping wound. Up to a range of 800 meters these rival horrors are one as bad as the other.

The gravity of the wounds depends on a multitude of conditions. On the rocks of San Juan, where the bullets ricochetted in wonderful fashion, the American surgeons reported frightful injuries. It was the same at Spion Kop, in the Transvaal. It used to be said, optimistically, that a bullet heated by friction in the barrel of the rifle would reach its object aseptic ized by friction; but this hope has been dispelled by the researches of von Koler, showing that the temperature of the projectile never comes within many degrees of that which is necessary for the destruction of microbes. The cruelty of the modern bullet has been augmented, too, with the increase of its rotation, so that it acts not only as a club, striking a heavy blow, and a perforating point, but also as a gimlet which lacerates the tissues.

But bullets, after all, are mild agents of destruction when compared with up-to-date shells. The shell wounds in the war of 1870 were only 91 per thousand; in the Manchurian campaign they were 176 per thousand; in the Balkan war of 1912 they were four times as numerous as in 1870. The shrapnel shell has the advantage (to its employer) of scattering destruction by means of some hundreds of small round bullets as well as the fragments of the shell itself. This "devil's watering-pot," as the Russian soldiers called it, works best within a radius of 10 to 30 meters; at 100 meters its "dewdrops" are still lively enough to penetrate 6 centimeters of pine board; at 300 meters a turban will protect the head from their effects. The tortuous incisions made by shrapnel are particularly difficult to disinfect. But in spite of all this, and though the ear of the most hardened veteran is said never to become accustomed to the death-song of shrapnel overhead, the common shell is really more terrible. Its fragments, brought to a very high temperature by the explosion, "burn the flesh so as to compel cries of agony which only morphine can quiet." Lastly, the large shells of the naval guns "not only cut like razors, but asphyxiate, amputate portions of the body and crush."

Dr. Helme's study of the movement of projectiles and its effects at various ranges, and on various tis-

snes, should be minutely interesting to those who love "the pomp and circumstance of glorious war." Its effects on bones, in particular, are classified as: (1) explosive; (2) comminutive; (3) contusive. The first, resulting when the range is not greater than 500 meters, splinters the bone so thoroughly as to explain the frequent accusations of using explosive bullets which have become a feature of modern war news. The second, proper to the zone of from 500 to 1,200 meters, is distinguished by the danger of bringing with it fragments of soiled clothing, carrying gangrene. These effects are observed only in the main body of the bone; in the spongy extremities there is less harm done except when the extravasation of blood brings on a diseased condition of the joint.

The effects of projectiles on soft tissues and organs containing liquids has led students of the subject to some highly interesting experiments. A bullet fired at an empty metal vessel makes a small hole both entering and leaving. But a bullet fired at the same kind of vessel filled with water, while it enters through a small hole, as before, leaves through a jagged opening 12 centimeters wide. This very fairly illustrates the effects of a bullet upon, say, a human stomach. The explanation advanced by the experimenter is: "In its passage, the bullet carries with it molecules, which are of very small mass, but move with great rapidity; these, being projected in all directions, have the effect of compressing the inert molecules (of the surrounding medium) and an outburst of the wall of the vessel follows at the egress of the projectile." And so it is that bullet wounds in the stomach, bladder, liver, intestines and head, received at short range, produce veritable explosions of these parts.

The writer concludes his discussion with the consolation, such as it is, that science and humanity appear in a much better light when we consider their achievements for the benefit of the good men who are wounded in their country's service.

Using an Economizer on a Hot-Water Heating System

By W. L. Durand

THE use of an economizer for heating water for a forced hot-water system is sufficiently novel to warrant a brief description of a recent installation of this character.

The original heating system was installed several years ago, and a live-steam heater and a 150 horse-power water-tube heating boiler were used for heating the water. Because of rapidly increasing demand on the heating system, as new buildings were added, the boiler and heater were of insufficient capacity. Furthermore, the space where the boiler was located was required for a steam boiler to take care of the increased load on the engines.

The power plant consists of 1,600 horse-power in water-tube boilers and an engine-low-pressure turbine plant. It was found that greater yearly economy was obtained by using the exhaust from the engines in a low-pressure condensing turbine than for heating the water for the heating system.

After examining several different plans, the final selection was made on the basis of the minimum total annual expense, although the first cost was the highest. The system has now been in satisfactory operation for the greater part of the present heating season. The leading features are as follows:

The 150 horse-power heating boiler was scrapped to make room for a new steam boiler, and heating apparatus was installed, partly in the form of an economizer and partly as a heating boiler, and sufficient altogether to provide for 65,000 square feet of radiation, which allows for all possible future expansion on the present property.

The flue gases left the boilers at from 500 to 600 deg. Fahr. An economizer was installed to utilize the available heat, which was estimated to furnish about one third of the total required for the system under maximum weather conditions. On this basis, moreover, the same estimate indicates a capacity sufficient to provide for 50 to 60 per cent of the total average heat required throughout the heating season. These estimates indicate the economy which the use of the economizer may be expected to secure.

The economizer consists of forty-four sections, each section 10 tubes wide and each tube 12 feet long, making a total of 7,200 square feet of heating surface. The branch pipes were increased from 4 to 10 inches to accommodate the large volume of water that is to be handled. One 2½-inch safety valve was placed on each end of the economizer. It was found impossible to locate the economizer in the power house, and it was, therefore, placed outside on structural-steel supports, as shown in the accompanying illustration. A house, of angle-iron frame and corrugated galvanized-iron covering, was built over the economizer to protect it from the weather. The roof is made in removable sections to permit of drawing tubes.

To provide the balance of the heating capacity, as required, a standard 285 horse-power water-tube boiler, with longitudinal drum, was installed, so that in case it should ever be desired for power purposes, no changes would be necessary. The only special feature is a baffle-plate in the center, so arranged as to prevent the water from short-circuiting through the drum. This baffle-plate is made in sections and can be taken down and removed through the manhole if the boiler is to be used for power purposes. The water enters the rear of the drum and flows down the rear header, up through the tubes, up the front header, and out at the front of the drum. Therefore, the flow of the water is in the same direction as the natural circulation in the boiler under steaming conditions.

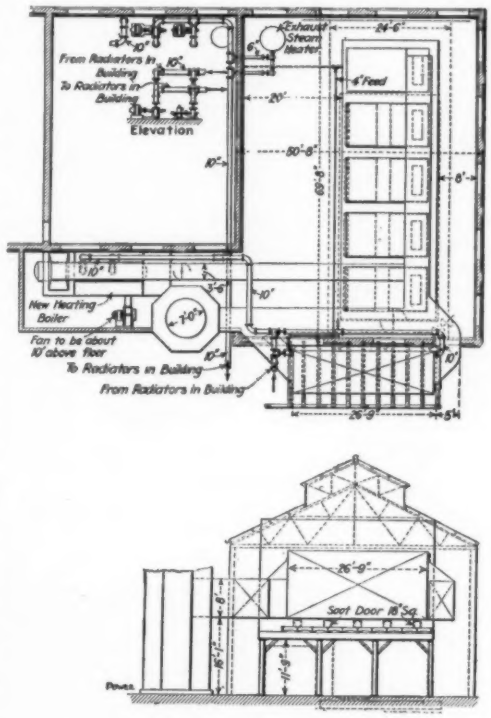
Both economizer and boiler are provided with bypass connections, so either can be run without the other.

The dampers in the main smoke breeching and in the intake to the economizer are controlled by a thermostat located in the hot-water pipe leaving the economizer.

* Reproduced from *Power*.

On account of the long run from the boiler to the main breeching, a balanced-draft system was installed to prevent the gases being blown out of the furnace door. The fan used is a centrifugal blower of the multi-vane type and is controlled by a thermostat located in the flow pipe leaving the boiler. By the use of the two thermostats any desired temperature is maintained in the circulating water.

The water is circulated by a double-suction, 1,500-gallon per minute centrifugal pump, directly connected to a motor. The present pump is kept in reserve for



Plan and elevation showing arrangement of heating system.

use in case of emergency. An interesting point may be mentioned in connection with the circulation of the water. Two methods of pumping have been tried with the system. First, pumping the water through the boiler and economizer or heater and then to the heating system. Second, connecting the suction side of the pump to the boiler and economizer and pumping direct to the heating system. It was found after trial that much better results were obtained with the latter method, which is the one now in use.

An added economy is gained in the use of the economizer by connecting it to the boiler-feed line so that during the summer when the economizer is not used for the heating system it can be used to heat the feed water. The feed water now enters the boiler at about 200 degrees; if it passes through the economizer it is raised to between 280 and 290 deg. Fahr.

In operating an installation of this kind, care should be taken to always keep the pump going. If the economizer is to be cut out or the pump stopped, the dampers to the economizer should be fully closed, and if possible the economizer emptied of water. If this is done no danger from an explosion need be feared.

Waste in the Brass Industry*

IN 1909, according to the Thirteenth Census,[1] 1,021 establishments making brass and bronze products spent for materials $99,228,000. If it be assumed that 80 per cent of that amount was for metal, $80,000,000 is spent annually for raw metals in such establishments, which do not comprise a third of the whole number of firms that melt brass and bronze.

No attempt was made to procure data on the tonnage melted, but ten firms—manufacturers of commodities listed under other headings in the census reports—did give such data, the total being 58,000,000 pounds for the ten firms, some of which are not exceptionally large. If a ratio of melt to metal bought of 2 to 1 be allowed, the figures quoted mean that 29,000,000 pounds of metal was bought at a value of about $4,000,000. In view of the known size of other firms, not included in the census classification under manufacturers of brass and bronze products, but furnishing replies to inquiries, a conservative estimate of the value of the metal bought by such firms would be about six times that bought by the ten firms mentioned, or, say, $24,000,000, which, with the $80,000,000 for those that are included, makes $104,000,000 spent for metal by the firms included in the census statistics and by those furnishing replies. As many other firms melting brass and bronze do not fall into either of these classes, it appears that the estimated value of all the metal used should be at least $120,000,000.

The consumption of copper in the United States in 1911 was about 680,000,000 pounds.[2] If two thirds of this total, or 450,000,000 pounds, be considered as having been used for making brass and bronze, and if the average copper content of the alloys used be assumed as 80 per cent, the deduction would be that about 560,000,000 pounds of brass and bronze products was made from new copper. It seems conservative to estimate that at least two thirds of the copper consumed in the country is in the form of brass and bronze, as Lathrop[3] states that one corporation making mainly wrought yellow brass uses in its various plants approximately a third of all the copper consumed in the United States. To this must be added the old metal used. Half as much old scrap or allowed ingot as new metal, that is, 280,000,000 pounds,[4] seems a fair estimate, so that 840,000,000 pounds should represent the total metal bought. The average value of brass and bronze being taken at 15 cents a pound, by this method of figuring $126,000,000 would be the value of the metal passing through the brass and bronze furnaces of the United States in a year. For purposes of computation the estimate of $120,000,000 has been taken.

A 2½ per cent melting loss, equivalent to a loss of 5 per cent on the metal bought, thus means $3,000,000 a year lost in metal alone. Could this be reduced to the 2½ per cent loss (equivalent to 1¼ per cent on the melt) shown by good practice, a saving of $1,500,000 a year would result. If the fuel consumption and crucible life were brought from the average practice up to good practice, and if furnaces that cut down or eliminate crucible cost and allow greater production with less labor cost were used wherever practicable, a saving of at least another half million would be made, or a total of $2,000,000 a year that the non-ferrous-alloy industry of the United States might save merely by bringing average furnace practice up to the standard of the best practice.

However it be figured, it is certain that the statement that the problem of the wastes in brass melting is one of the greatest importance in the waste of alloy manufacture[5] is correct.

* From "Blast Furnace Practice in the United States," by H. W. Gillett. Bulletin 73, Bureau of Mines, U. S. Geological Survey.

[1] Thirteenth Census, Advance Bulletin, "Statistics of Manufacturers," 1910, p. 75.

[2] "Mineral Industry," 1911, p. 165.

[3] Lathrop, W. S., "The Brass Industry of Connecticut," 1909, p. 127.

[4] U. S. Geological Survey Press Bulletin 117, "The Country's Enormous Junk Heap," June, 1913, p. 2. The recovery of secondary copper by smelters and refiners in 1912 is here given as 137,507 tons. This figure is on copper and the copper content of the recovered brass. That for remelted brass (alloyed ingot) is 101,437 tons, or nearly 203,000,000 pounds. Besides this, in foundries themselves there is a large remelt of old scrap, which does not reach the refiner. See also *Foundry*, vol. 41, 1913, p. 384.

[5] Parsons, C. L., "Notes on Mineral Wastes," Bulletin 47, Bureau of Mines, 1912, p. 20.

Modern Turret Fortifications

New Construction to Oppose Increasing Power of Guns

THE history of fortification is as old as that of nations. New requirements, born of the incessant improvement of artillery, have modified its details, but its object remains the same as always: to allow the defender of a post to hold out against superior forces. For this purpose it is necessary to create an effective obstacle to the approach of the enemy, and also to provide shelters in which the defenders may be protected from the fire of the enemy, while remaining free to use their own guns effectively.

Vauban inclosed a wide and deep ditch between two thick walls, the escarpment on the inner side and the counterscarp on the side toward the enemy, and we find these elements repeated in all the old forts, including those which were built in the reconstruction of the French system of defense after the war of 1870. The forts surrounding Paris are classical examples of this construction.

The New Principles of Fortifications.—The newest forts present a totally different appearance. The ditch remains, but the huge earthworks of the old forts, 30 or more feet in height, have been abandoned as too vulnerable under the very accurate fire of modern artillery. In the most important French forts these great earthworks have been replaced by much lower but much thicker parapets, which are just high enough to give the defenders a good view of the surrounding country. The experience of the fort of Malmaison in 1886, following the introduction of highly charged torpedoes, proved that a thickness of at least 40 feet of earth is required to give certain protection against these terrible engines of destruction. Parapets of 45 or 50 feet in thickness are found in many of the newest forts. The ditch is constructed on a new plan. On the side toward the enemy, a counterscarp about 15 feet high is retained, but this is now constructed of cement concrete and is at least 6 feet broad at the top. By this construction the joints of ordinary masonry are eliminated, and the wall forms a homogeneous mass of remarkable strength. It is reinforced by a mass of broken stone, 10 feet thick, placed in front of it, which constitutes an obstacle to undermining by shells striking in front of the concrete wall and bursting underground. The escarpment on the inside of the ditch has entirely disappeared, in its original form at least. Now the bank is allowed to have its natural slope from the firing line to the bottom of the ditch, and a strong grille of barbed wire imbedded in concrete replaces the stone wall of the old type, which is too easily destroyed by persistent artillery fire. Finally, as the defender cannot see the bottom of the ditch from the top of the parapet, chambers of concrete with very thick walls, known as flanking coffers, are constructed at each end of the counterscarp. From these coffers the ditch can be raked by the fire of machine guns and other rapid-fire guns, driving away any enemy rash enough and skillful enough to enter the ditch. At present, more than ever, before, it is imperatively necessary to protect the defenders of the fort against bombardment, which now may be extremely effective. For this purpose, shelters are constructed beneath the parapet, with concrete walls 8 feet thick, and in these shelters the troops detailed for service on the rampart take refuge during the entire fire of the enemy. The remainder of the garrison is sheltered in barracks, also built of concrete and furnished with all the indispensable conveniences of daily life. All of these rooms, including the flanking coffers, the shelters on the ramparts, the barracks, the casemates, and the turrets described below, are connected by a system of underground passages, through which the members of the garrison can circulate freely without being exposed to the fire of the enemy. Only a few sentinels keep watch on the ramparts, from armored lookout towers, for the purpose of giving warning of the enemy's approach.

Gun Turrets.—The precision of modern gun fire makes useless all unprotected pieces of artillery, which would naturally be the chief points of attack by the enemy. Hence the large guns, which were formerly placed in the forts, are now collected in batteries behind the line of forts, and the latter contain only very small numbers of guns, devised for special purposes. It is necessary for a fort to be able to constitute its own defense, and to protect to the last moment the guns which command an important point. These guns might be mounted in casemates of concrete with walls 8 feet thick, which would afford effective protection against the enemy's fire. The openings through which the guns would be fired must in this case be made extremely narrow, in order to avoid making them particularly vulnerable, but guns protected in this way could be fired only in a very small number of directions. The adoption of the revolving armored turret is a much more satisfactory although more costly solution of the problem. A gun turret consists essentially of a cylinder made of armor plates, revolving in a well lined with concrete, which contains the necessary machinery and magazines in addition to the guns and the gunners. The concrete walls which line the shaft vary in thickness from 10 to 16 feet, according to the type of turret, and are protected, on the side toward the enemy, by a mass of broken stone and an earthwork at least 30 feet thick. In order to obviate the possibility of a shell striking the edge of the well and detaching fragments of concrete, which might fall between the wall and the turret and prevent the rotation of the latter, the mouth of the well is formed of a ring of hard cast iron, which affords additional protection, and which furthermore provides a way of communication around the turret. At first, a simple rotating turret was employed (Fig. 3). It consisted of an arched roof of hard cast iron, 16 inches thick, supported by a frame of steel plates about 1½ inches thick. The roof alone appeared above the massive concrete wall of the well. Hence a turret, carrying two 6-inch guns, offered a target only 3½ feet high and about 18 feet wide. The turret was turned by hand, by means of

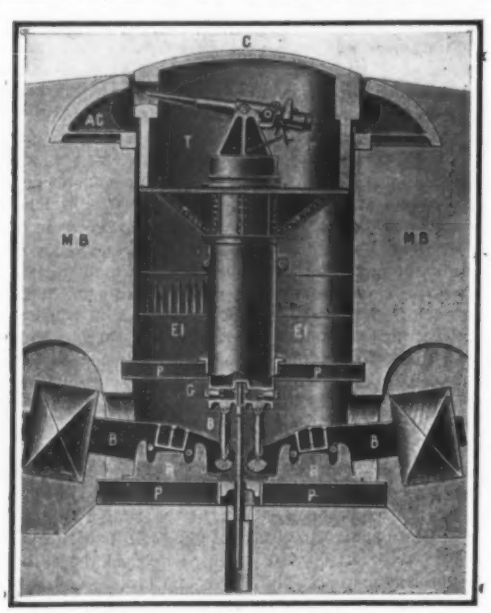


Fig. 7.—Section of Galopin disappearing turret.

C, armored roof and hood; AC, armored rim; T, firing chamber; MB, concrete; El, operating room; B, arms of counterweights; R, rollers; P, iron beams.

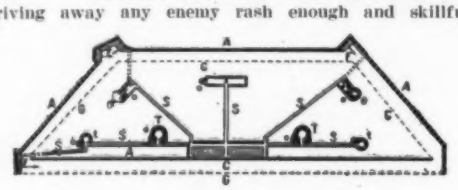


Fig. 1.—Plan of a modern fort.

A, counterscarp of concrete 8 feet thick; G, barbed grills forming escarpment; C, barracks; F, flanking coffers; S S, underground passages; T t, gun turrets; a, figting shelter.

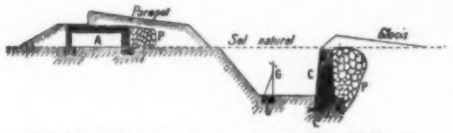


Fig. 2.—Section of a parapet and ditch of a modern fort.

A, fighting shelter; P, broken stone; G, escarpment grille; b, concrete; C, counterscarp.

Fig. 3.—Earliest type of revolving turret.

Fig. 4.—Second type of turret with guns protruding.

Fig. 5.—Turret in disappearing position.

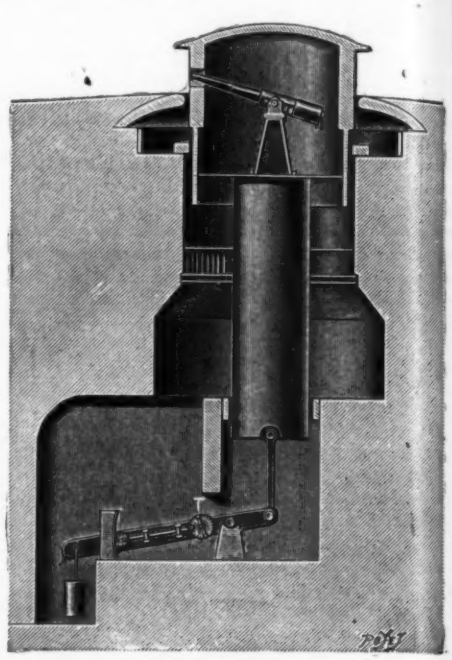


Fig. 8.—Section of 3-inch disappearing turret in firing position.

Fig. 6.—Conning tower.

gearing, the movement being facilitated by raising the whole mass, by means of a hydraulic press acting upon the pivot of the turret, so that only 1/10 of the weight rested upon the wheels on which it turned, and the remainder was supported by the cylinder of the press. The increase in the use of armor and the continual improvement in artillery led to the construction of the second type of turret (Fig. 4), which is made of laminated iron and is much less visible. This was soon superseded by the disappearing turret (Figs. 5, 7, and 8), which is the only type now employed. In this turret the guns are retracted entirely within the armored portion. The portholes, which were very visible in the earlier turrets, are entirely covered, and they emerge from the concrete well only during the time required for firing.

The disappearing turret is constructed for one or two 6-inch guns, two 3-inch rapid fire guns or two machine guns. The type, however, does not vary essentially. The moving mass is counterbalanced by weights, as in the turret already described, but the improvements introduced into this system of counterbalancing by Galopin have made the turret for two guns the remarkably effective weapon which is now installed in our forts. The fulcrums of the counterweights move on rocker bearings, so that the length of the lever arm varies during the motion in such a manner that the turret reaches its final position with zero velocity. The turret being in its position of eclipse, and offering only its low roof as a target to the enemy's fire, the guns are loaded, and are aimed by the indirect method, by means of drawn plans. Meanwhile the counterweight has been wound up, and when all is ready, at the word of command, a catch is released and the turret rises. At the top of its course, the two guns are discharged automatically by the closure of an electric circuit, and the turret immediately sinks. The time which elapses between the word of command and the complete disappearance of the turret is only five seconds, and two shots can be fired every 90 seconds.

The 3-inch gun turrets operate in a similar manner. The machine-gun turrets are somewhat different. As they are much lighter, they can be moved directly by the gunners, and so easily that they can be caused to sweep the whole crest of the glacis during the volley.

The thickness of the walls varies with the type of turret. For the large calibers it is about 12 inches, a thickness which offers an effective defense against modern siege guns. In 1886 the Roumanian government, desirous of equipping its forts with armored turrets, made a very elaborate series of experiments with a French and a German turret. Neither turret was at all injured by either the explosive or the armor-piercing projectiles of that day. Since that time the precision of fire has greatly increased, but the force of projectiles has undergone less change, so that it is probable that these turrets would still withstand a siege without serious damage. Experiments are now being made with an 11-inch mortar, throwing a shell weighing 550 pounds. The nearly vertical fire of these mortars would certainly be very dangerous for the roofs of disappearing turrets, but it should be remembered that in the Roumanian experiments 164 shells were discharged from a German rifled mortar of 8 inches caliber, at a distance of less than 3,000 yards, without making a single hit. The French disappearing turrets are constructed in accordance with the results of experiments made in 1887, 1905, and 1906. In regard to their strength, they inspire perfect confidence, and as their fire is very accurate, they constitute excellent weapons. Unfortunately, they are very costly, like all modern fortifications.—*La Nature.*

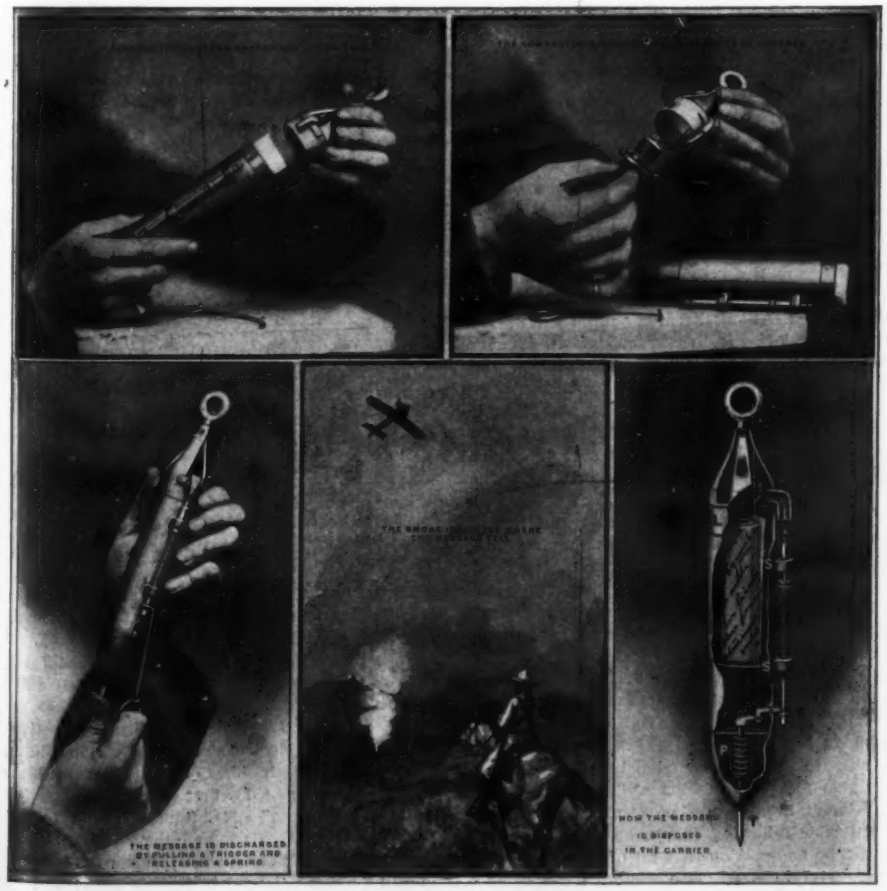
Throwing Military Messages from Aeroplanes

As the flying machine developed, the need of subsidiary apparatus became apparent. Military men soon demanded the installation of wireless apparatus, guns, armor and similar accessories. While a great deal of experimenting has been done to give them what they want, it can hardly be said that a very great measure of success has as yet been attained. Especially is this true of the wireless equipment. The sending apparatus which can be carried on an aeroplane is necessarily of very small range, and the receiving apparatus must struggle with the difficulty of interference. Some day these objections will undoubtedly be overcome, but until they are, a French inventor and aviator, Paul Fugairon, believes that some such apparatus as he has invented and tested near Brest will be most acceptable to military men. With his invention a message can be dropped in full flight by an aviator who is sufficiently near his destination, the craft returning immediately at full speed to the enemy's position. There is no danger that the message will be blown away by the wind, or that it will be lost or damaged in mud, dust, high grass, and heavy foliage.

As the accompanying diagram shows, the apparatus consists of a hollow cylinder, in which the message is received. At its base the cylinder is inclosed by an ogival member *P* into which lead has been poured, so that the apparatus will always drop upon the point *T*, which passes freely through the lead. At the other end of the cylinder is a cover *L*, the top of which is formed like a lantern with four open windows *C*. Within the cover are four clamps to hold material for a Bengal fire. This is ignited by the explosion of a cap of mercury fulminate. As the apparatus strikes the ground, the cap is exploded by the firing pin *B*, which is guided in two brackets, and the flame of the explosion being conducted to the Bengal-fire material through the curved tube *U*. A lever mechanism here connects the firing pin *B* with the point *T* the lever mechanism being held in a position of rest by the spring *R*. As soon as the point *T* penetrates the ground the spring *R* is compressed, the lever mechanism is operated to pull the pin *B* backward a short distance, and to release it immediately afterward. The firing spring, which was put under tension before the message was dropped, is thus liberated, so that the pin *B* is forced against the fulminate cap.

The exceedingly bright Bengal fire which flashes up can be seen not only at night, but in daytime as well. What is more, it burns long enough to allow a soldier who has been watching for it to cover a distance of 300 yards to the spot where it has fallen, and whither its light guides him.

Obviously not only written messages, but also sketches and rough maps, can be "canned" in this way.



By means of this simple device messages can be discharged from an aeroplane with the certainty that they will be found. As soon as the device strikes the ground Bengal fire is ignited, and the resultant smoke indicates where the message is to be looked for.

Limitations of the Submarine

A CORRESPONDENT in *The Engineer* discusses this now important question in a comprehensive way, and comes to the apparently logical conclusion that the powers of the submarine have been overestimated by the lay public.

"There is great danger of losing one's sense of proportion amid the welter of statements recently made regarding the value of the submarine as a naval unit in time of war. That this type of vessel is a serious factor, and one to be given a prominent place in any balancing of naval forces is not to be denied; and that it is a rapidly developing arm is unquestionable. The potentiality that it possesses for becoming a more serious factor still in the near future is an unknown quantity, but there seems little doubt that the type will increase in size, power, speed, and offensive capacity. It must be noted, however, that it has definite limitations in action, which are imposed upon it by reason of the very qualities it possesses as an attacking force. It attains comparatively slow movement even on the surface, is very slow when submerged, and, above all, is exceedingly vulnerable. To assert that the submarine will drive the battleship off the seas is to follow our neighbors of France in a misconception of relative values, which has placed them in an unenviable position with regard to the larger units, an error which recent naval policy in that country is designed to retrieve. It is quite true that the submarine in its present state of development, and in its future possibilities, is a serious menace to the battleship, unless necessary precautions be taken, but so is a lightly armed body of sharpshooters a menace to an army on the march; the idea that the one can ever take the place of the other, however, is inconceivable. It can neither move quickly, nor inflict heavy blows, such as big guns are capable of delivering; it could not provide efficient convoy for trade routes, nor be fully effective in heavy weather at sea. The functions of the submarine approximate more nearly to those of guerrilla warfare than to those of open battle. The vessel is designed to deliver powerful blows by means of insidious and unsuspected torpedo attack, and for this reason might be exceedingly useful in preventing effective blockade or in attacking hostile ships when in harbor; on the high seas it is a different matter. What, then, are the conditions which limit the scope of its effectiveness?

"It may be assumed that the general design of these vessels has become more or less fixed; when on the surface they differ very little in appearance from an ordinary destroyer, at the forward end especially, and can therefore keep the sea in moderately heavy weather; but even the largest of them, say up to 200 feet in length, have a maximum speed on the surface, and in calm weather of only about 17 knots, and when submerged 10 knots. It will be seen, then, that even for such a large submarine to approach a battleship on the alert against attack is no easy matter; the surface speed of 17 knots can only be used to bring the vessel into the approximate vicinity of her foe; she dare not make her approach known by showing herself on the surface; it is necessary for her to dive and to continue the attack at the more moderate speed of 10 knots until coming within the effective striking distance of the tor-

pedo. The range of modern torpedoes is very great, and the practice made with them under peace conditions is very accurate, but it would probably be a different thing to make certain of a hit under war conditions when it may be supposed that the quarry would be kept on the move, possibly varying both speed and direction in order to confuse the aim of her opponent, for it cannot be assumed that any commander of a battleship would be quiescent and allow an easy attack to be made on his ship if he were in a region where such an attack was to be feared. The submarine must therefore approach to within a reasonable distance, and to do this must come to the surface periodically in order to use her periscopes, taking the risk of escaping observation. If she is successful in this and can discharge two or more of her forward torpedoes there is still a great chance of missing her mark, for the progression of a submarine is not a perfectly regular thing when she is submerged. The depth of submersion is regulated by the diving rudders, and as a submerged body is very easily diverted in the vertical direction, a small force is sufficient to cause change of inclination of the boat, with the result that the vessel's course is a more or less sinuous one, even in calm weather. The successful finding of an erratically moving battleship by a torpedo delivered by a submarine which is also moving somewhat erratically is not the easy proposition that it may appear to be on paper. It may be assumed that the submarine will accept any risk in order to deliver a successful blow on an opponent, which represents such an immense value to the enemy, but, with all the goodwill in the world and the most devoted endeavor, it may prove a task impossible of accomplishment unless a combined attack be made by more than one boat.

"The commander of a submarine has many things to watch before he can discharge his torpedo with any probability of success. His own vessel must be navigated in a double sense, that is, both horizontally and vertically, with the added difficulty that the vertical movement is very sensitive to small differences of vertical force. He must watch his enemy and judge accurately both her course and speed; he must also keep an eye on the horizon for possible foes other than the one to which his attention is mainly devoted; and all this must be done by means of periodic peeps of a few seconds' duration from the telescopic periscopes. It is well known that very few of the torpedoes which were discharged by destroyers in the Russo-Japanese war ever found their mark, and it is not likely that the submarine would be more successful than the destroyer in this respect unless it be found to be more possible than appears probable, to make a comparatively close approach to the ever vigilant mark before discharging the weapon.

"Safety of the large vessel would seem to be centered in her power of keeping a speed greater than that of the submerged vessel, and in continually changing course, so that it shall be made necessary for the submarine to expose her periscope at intervals, for that is the only means of locating her position unless the aid of seaplanes be invoked. Lack of submerged speed is therefore a most pronounced limitation of the submarine, and one that cannot easily be remedied. The cells which supply current to the motor which drives the ship when submerged must be of sufficient capacity to give her a large radius of action, or she may be obliged to come to the surface, and thus fall as easy prey to her enemies. If the battery runs out, the vessel must either come up or adopt the dangerous alternative of filling her tanks and lying on the bottom until the danger has passed; this, it is needless to say, is a last resort, which could only be carried out in comparatively shallow water. There is necessarily a much greater risk in submarines from errors of navigation than in ordinary vessels, and this risk in the heat of action would probably be accentuated. Whether this is a serious item or not it is impossible to decide in absence of actual war experience; present-day design provides much greater longitudinal stability than was possessed by the earlier types, and erratic diving is not now so likely to occur, but the personal element is always present, and it is this element which is liable to variation in times of stress and excitement. The third limitation is vulnerability. Submarines are naturally liable to fatal damage with little injury to the fabric of the hull; when in the submerged condition a very small quantity of water is sufficient to change trim and reduce the reserve of buoyancy. This limitation is a very obvious one, and is inherent in the design. A considerable amount of intruded water can be easily dealt with by the pumps and compressed air plant, and there is generally as a last resort the provision of a heavy keel which can be dropped in emergency, so enabling a damaged submarine to be brought to the surface; but these qualities may become practically useless in time of war, for as soon as the boat appears above water she falls an easy prey to her surface foes. Looked at broadly, this danger to the submarine does not count for much. Sacrifice of the whole vessel would be amply justified at the price of sinking or even disabling a much larger unit, but the moral effect of these possibilities of disaster must count for something to the crew, however brave they may be, and may affect to some extent the conduct of their operations.

"These vessels are really naval guerrillas, and must be tackled in the same manner as similar foes on land; they must be attacked and prevented from harassing large vessels by what may be called torpedo sniping. The battleship is too valuable a unit to be risked on such work; smaller classes of ships are better fitted to scour the sea with the aid of seaplanes as scouts, and to make the task of submarines an exceedingly difficult one. If battleships be threatened, in spite of the protecting screen drawn round them, they still have their great advantage of speed and mobility further to increase the difficulty the submarine has in placing a successful blow. The great mistake would be to ignore the changed conditions brought about by the advent of the submarine as a force to be seriously reckoned with and to fail in making adequate provision to cope with the danger.

"It may be presumed that naval authorities all over the world are fully alive to the position, and will not allow themselves to be unduly swayed by those who, lacking a proper sense of proportion and of relative values, see the end of all things in the growth of the new arm, and make the unwarranted assumption that the battleship is doomed, whereas all that has happened is a new method of attack has to be met by other methods of defense than those which have hitherto been necessary; and that the provision of submarines must be proportionately large to match those of possible foes."

Age of Production in Invention and Other Fields

Genius of Inventors Culminates Early in Life

By William I. Wyman

GENIUS has been defined as the ability to take great pains, while the common conception of this quality is facility of accomplishment without undue excess of effort. Probably the truth is an aggregate of these apparently contradictory ideas. In examining the achievements of men of transcendent note it is to be observed that in most cases, especially in scientific and artistic endeavors, they gave very early in life decided manifestations of unusual brilliancy. The consciousness of superior powers is, naturally, accompanied by a driving desire to give them expression, and thus we often see in the same individual powers of acutest imagination and quickest comprehension coupled with tireless energy and mastery of endless detail. Napoleon was quick to see and almost as quick to act, but he worked longer and more intensely than any of his compeers. Mozart and Raphael, highly precocious, whose arts came to them with excessive ease, left a prodigious heritage of their drudgery in the very short time they lived, while the enormous output of super-men like Newton, the scientist, Shakespeare, the dramatist, Balzac, the novelist, Rubens, the painter, and Wagner, the composer, testified to their absorption in their work as well as to their brilliancy of accomplishment.

In reviewing the careers of the more brilliant inventors, we find that they gave evidence early in life of a decided bent toward mechanics or applied science, and that their capacity for drudgerous detail and extended, intense effort was the common hall-mark of their tribe. We do not find here such unusual outbursts of precocity as frequently distinguish the tender age of the mathematical or musical genius. Almost always the great masters of music or pure science have been youthful prodigies. Mozart composed at 5, Handel at 11, while Beethoven was second court musician at 14. Pascal at 16 wrote an original treatise on conic sections, Lagrange at 19 wrote a paper which would have immortalized the maturest mathematician, and Laplace established his primacy in the scientific world before he was 21. Henry Smith, the great English mathematician, taught himself Greek as a child of four, while Clerk Maxwell intelligently (!) investigated the mysteries of bell-wiring at the somewhat less mature age of 3. But serviceable invention calls for some exercise of the maturer faculties. Imagination and inspiration may ripen exceedingly early in life, but invention, while depending in great measure upon these qualities, has also close relation to the practical, to things which require experience and passage of years to absorb and appreciate. So it is entirely natural to expect that many of the greatest inventions should have been introduced when their authors were fairly well along in years, but what is remarkable to note is the youthfulness of the creators of a great many of the most important and revolutionary inventions at the time of introduction. Perkin invented the first aniline dye at 18—thus a mere boy laid the foundations of the immense coal-tar industry; McCormick was a youth of 22 when he made his first reaper, whose importance as an industrial factor is scarcely overshadowed by any other invention since the steam-engine; Westinghouse and Marconi about reached their majority when their original creations were first published to the world, and what the air-brake is or wireless has done is to record the high-water mark in inventive progress; the thermo-electrolytic reduction of aluminium was simultaneously discovered by Hall in this country and Heroult in France, both at the age of 23, and these two young men, just one remove from boyhood, gave to industry a new useful metal, which bids fair to rank next to copper in commercial importance; and only two years later, at 25, Heroult perfected the first serviceable commercial electric-furnace, whose transcendent importance as a factor in fundamental industrial operations we are only beginning to realize.

If we were to take an excursion into the realms of the disputable and risk making a list of the twenty greatest primary inventions of modern times, we would present the table following (chronologically arranged).

There can be no question that all of these inventions are pioneer and invested with historical importance, and whether or not a better list can be prepared, it is safe to draw conclusions from the table presented. We find the average age of production about 32, at an age when extremely few men, by and large, have made their mark. Half of these contributions, all of epoch-making character, having a revolutionary or unusually stimulating effect on some industry, or creating some new and important art, were made before their progenitors reached 30, while only four, or 20 per cent, were contributed by men over 40.

TITLE AND AGE OF INVENTOR AT TIME OF INTRODUCTION.

Title.	Age.
Steam engine	29
Cotton gin	27
Photography	40
Reaper	22
Telegraph	46
Vulcanization (rubber)	39
Sewing machine	26
Bessemer process	42
First coal-tar product	18
Regenerative furnace (Fred. & W. Siemens)	30-34
Dynamo	44
Air-brake	22
Telephone	29
Incandescent lamp	32
Gasoline engine	50
Steam turbine	29
Aluminium (Hall-Heroult)	23
Induction motor	31
Wireless telegraphy	22
Aeroplane (Wright Brothers)	34-38

If we enlarge the list and include inventions of inferior importance only to what has already been listed by adding the spinning-jenny (at 25), ether as an anesthetic (27), first synthetic products (28), the phonograph (30), carbon-zinc electric cell (30), linotype (30), steam hammer (30), ophthalmoscope (30), electric-welding (33), first modern locomotive (33), dynamite (34), electric-steel (35), cotton-spinning machine (36), hot-air blast for metallurgical furnaces (36), safety lamp (37), first practical gas engine (37), Fulton's "Clermont" (42), Bunsen burner (44), kinetoscope (46), X-ray (50), and the Jacquard loom (51), the average age is advanced to about 33.5. If the list is still further enlarged to include about 40 additional but slightly less prominent inventions, the average age of production moves up almost two years, to 35.3. Allowing every reasonable latitude of choice and confining our list of greatest inventions to 25 as data for judgment, we have no reason to alter the conclusion derived

from a study of the first table. Of achievements in applied science of the very first order, those of historical and vital importance, more were invented before 33 than after, and exceptionally few were created after their sponsors had reached their prime. From 27 to 36 appear to be the most active and most ingenious years of the greatest inventors, the lower 30's showing the peak of inventive effort. The young man came into his own at this time of life with the acceleration of electrical development from 1880 to 1890. Edison, Brush, and Thomson were about 30 when they undertook the pioneer task of utilizing electricity in generation, transmission and lighting, and Sprague was scarcely that age when he installed the first modern trolley system in Richmond, while William Stanley was considerably younger than thirty when he first wrestled with the problems connected with utilizing alternating current, and Tesla just over the line when his induction motor made practical the generation and transmission of high-tension and polyphase currents.

Atrophy of the creative powers by no means exerts its baneful touch after the Osierian 40 years have arrived. Some mighty big advances were made in the industrial arts by men in the 40's—notably the Bessemer process, the telegraph, gasoline engine, the kinetoscope, electroplating, voltaic pile, siphon recorder, and Daniell cell. But the half-century mark seems to define the limit of inspirational endeavor. Bunsen invented a vapor calorimeter at 76, and M. G. Farmer was active beyond 60 as is Edison to-day, but Harvey's process of hardening armor plate, when he was 67, is the only instance the writer has been able to find of a primary invention of large industrial or social importance that was given to the world beyond touching distance of 50. Inventive genius, while flickering out at such age, does so with a strong dying gasp, for at 50 or 51 were invented the gasoline engine, the X-ray machine, the Jacquard loom, and the modern mariners compass.

It is interesting to compare the age of achievement of inventors with those of men made famous in other walks of life. As already noted, the genius of great mathematicians and musicians almost universally breaks out at an extremely tender age. Child wonders are by no means scarce among the notabilities in other vocations. Jonathan Edwards at 10 wrote a paper on the immateriality of the soul; Goethe at 8 knew something of Latin, Greek, French, and Italian, and presumably was master of his own difficult tongue; Milton at 15 composed excellent Latin verse; and Alexander Hamilton at 13 wrote letters creditable to one of matured mind; while before he arrived at 17, Raphael's work was indistinguishable in quality from the leading exponent of the greatest art school of the time. Of the great conquerors of history, four stand out in startlingly splendid isolation. Alexander was master of the world at 25, Hannibal at 26 was commander-in-chief of the Carthagenian army, and Napoleon proved himself the greatest general of modern times at 27. Cæsar was 40 before he was permitted to find opportunity to display his terrible aptness for war, and was the only one of the quartette who was beyond the influence of boyhood when he made his military mark. And yet Moltke, the greatest military strategist of our time, remained in comparative obscurity until he was 66, and did not take his place among the great historical figures until the Franco-Prussian war, at a time when the Psalmist's allotment of three-score and ten had expired. As a rule, however, men of action and men of affairs do not come to years more fruitful of fame until they are well above 40, because the time spent in apprenticeship and service and step-by-step progress through a number of competitive grades are such large factors in determining their position. Prominent statesmen, financiers, and captains-of-industry, are frequently men who may be called old, and often great military and naval engagements have been conducted by men some distance beyond their prime. In fact, it is an exception when a statesman or financier has acquired fame in his early manhood. The highest flights of the imagination, the acutest insights into scientific truth, and the most dazzling of military operations have often been the products of comparative immaturity, but the more humdrum activities in the affairs of state or in the conduct of trade and finance require leadership of tested experience. It is this fact which makes the records of William Pitt and Alexander Hamilton (one in becoming prime minister of England at 24, and the other in being the Colonies' leading financial authority at the same age) so extraordinary—not in the inherent brilliancy of their performances, but in the extreme rarity of instances of that kind.

Inventors, being partly men of science, partly men of imagination, and to a great extent men of affairs, do not leave a record of precocity typical of the first or mature so late as the last. Their records are comparable in great degree to those of noted writers, men of the creative type and of artistic perception. Thus Milton wrote "Comus" at 26 and completed "Paradise Lost," his last great work, at 57. Shakespeare wrote his first great poem at 29 and died at 52; Thackeray published his "Vanity Fair" at 35 and reached the height of his powers with his "Newcomes" at 43; and Dickens acquired fame at 24 by his "Pickwick Papers," reached his high-water mark at 38 with his "David Copperfield," and exhausted his genius not long after 50. Examples like this could be multiplied *ad libitum*, although it is curious to note a rare departure in DuMaurier and DeMorgan, both of whom took their first fling at novel writing when they were past their prime—one at 57 and the other at 67—and achieved success and fame in the attempt. Our most famous inventor, Edison, invented the stock-ticker at 24, the phonograph at 30, incandescent lamp at 32, devised the first central station at 35, and invented the kinetoscope at 46—the comparison stops here, as his record of achievement is by no means closed.

A TABLE OF IMPORTANT INVENTIONS.

Inventor.	Age.	Invention.	Date (Patented, Operated or Disclosed).
Perkin	18	Aniline Dye	1856
Siemens, Wm	20	Steam Engine Governor	1843
Bessemer	21	Electroplating Lead with Copper	1813
Colt	21	Revolver	1835
Marconi	21	Wireless (first patent)	1896
Westinghouse	22	Air-brake	1868
McCormick	22	First Reaper built	1831
Hall	23	Aluminium Reduction	1886
Heroult	23	Aluminium Reduction	1886
Edison	24	Stock Ticker	1871
Ellis	24*	Non-caustic Varnish Remover	1902
Crompton	25	Spinning-Jenny	1778
McCormick	25	Reaper (first patented)	1834
Marconi	25	Wireless (successful operation)	1900
Howe	26	Sewing Machine	1845
Whitney	27	Cotton Gin	1792
Davy	27	Voltaic Arc	1805
Ericsson	27	Steam Fire Engine	1830
Dr. Morton	27	Ether as Anesthetic	1846
Edison	27	Quadruplex Telegraph	1874
Brush	27	Dynamo and Arc Lamp	1876
Wellsbach	27	Gas Burner	1885
Wohler	28	Synthetic Organic Compound	1828
Watt	29	Steam Engine (successful operation)	1765
Whitworth	29	Planer	1832
Farmer	29	Electric Cooker	1849
Bell	29	Telephone	1876
Parsons	29*	First Steam Turbine Produced	1884
Baekeland	29	Velox Paper	*1892
Faraday	30	Principle of Electric Motor	1821
Nasmyth	30	Steam Hammer	1838
Bunsen	30	Carbon Zinc Cell	1841
Siemens, Fred	30	First Regenerative Furnace Patent	1856
Edison	30	Phonograph	1877
Helmholtz	30	Ophthalmoscope	
Mergenthaler	30	First Linotype	1884
Farmer	31	Electric Fire Alarm Telegraph	1851
Tesla	31	Polyphase Current Motor	1888
Edison	32	Carbon Filament	1879
Stephenson	33	His First Locomotive	1814
Thomson, Elihu	33	Electric Welding	1886
Hoe	34	Rotary Press	1846
Siemens, Wm	34	First Regenerative Furnace Patent	1857
Otto	34	First Successful Gas Engine	1866
Nobel	34	Dynamite	1867
Eastman	34	Kodak Camera	1888
Wright, O	34	Aeroplane	1905
Edison	35	Central Station Distribution	1882
Heroult	35	Electric Steel	1898
Acheson	35	Carborundum	1891
Arkwright	36	Cotton Spinning Machine	1768
Fulton	36	Submarine	1801
Neilson	36	Hot Air Blast	1828
Mergenthaler	36	First Successful Linotype	1890
Davy	37	Safety Lamp	1815
Wright, W	38	Aeroplane	1905
Watt	38	Steam Engine Perfected	1774
Siemens, Wm	38	Regenerative Furnace Perfected	1861
McKay	39	Shoe Sewing Machine	1860
Goodyear	39	Vulcanization of Rubber	1839
Gayley	39	Hot Air Dry Blast	1894
Diesel	39	Internal Combustion Motor	1897
Daguerre	40	Photography	1829
Westinghouse	40	Quick Acting Brake	1886
Acheson	40	Artificial Graphite	1896
Bessemer	42	Convertor	1855
Fulton	42	Steamboat	1807
Kelvin, Lord	43	Siphon-Recorder	*1867
Cort	44	Reverbatory Puddling Furnace	1784
Brugnatelli	44	Electroplating	1805
Bunsen	44	Burner	1855
Siemens, Wm	44	Dynamo (with Werner Siemens)	1867
Siemens, Wm	44	Open Hearth Process	1867
Otto	44	Finished Gas Engine	1876
Taylor	44	High Speed Steel	1900
Stevenson	45	First Successful Locomotive Operated	1826
Daniell	46	Battery Cell	1836
Morse	46	Telegraph	1837
Edison	46	Kinetoscope	1893
Volta	47	Voltaic Pile	1792
Kelvin, Lord	50	Mariners' Compass, Modern	*1874
Daimler	50	Gasoline Engine	1884
Roentgen	50	X-ray Machine	1895
Siemens, Werner	51	Dynamo (with Wm. Siemens)	1867
Jacquard	51	Loom	1801
Ericsson	52	Hot Air Engine	1855
Daimler	52	Gasoline Vehicle	1886
Morse	53	Telegraphy Publicly Demonstrated	1844
Ericsson	60	Monitor	1863
Harvey	67	Harveyized Steel	1891

* Approximately.

Distribution of Nebulæ

A DISCUSSION of a systematic search for nebulæ in Kapteyn's "Selected Areas," by E. A. Fath is given in the *Astronomical Journal*, plates having been taken covering 139 out of the 206 regions comprising the scheme. The exposures were made with the 60-inch reflector at Mount Wilson, and each lasted one hour. A number of new nebulæ are noted, and an interesting series of conclusions as to the general distribution are given. The concentration of nebulæ near the north galactic pole is very noticeable, but there are great variations in the density of distribution. There is a complete absence of these nebulæ where the Milky Way crosses the sky.

Prism With Curved Faces

ON previous occasions, Mr. C. Féry has, and he now describes in the *Journal de Physique*, how a prism with curved faces, one of the curved faces being made reflecting, can be used in the construction of a spectrograph; how such prisms may be employed generally to give a pure spectrum, even though the incident beam is not parallel. If the beam is divergent a concave face is used for the incident light, and a convex face when a convergent beam is employed. The diacaustic of such a prism is situated on a circle, whatever the dispersive properties of the material, and this circle contains the centers of the curved faces of the prism. A description is given of the way in which prisms with curved faces may be used (i) for transforming a convergent beam into a spectral image, e. g., the image of a star furnished by an astronomical objective; (ii) for the study of infra-red spectra; and (iii) for the study of ultra-violet spectra.

How Dirigible Airships Are Charged With Gas on the Battlefield

Portable Plants for Military Use

THE progress recently made in developing the spherical balloon and especially the airship for military or other uses, has caused increased attention to be paid to methods for producing hydrogen gas in large quantities to meet the growing needs and in a sufficiently pure state. Of late the extensive use of airships in some countries, as a part of the army outfit, has led to a search for suitable hydrogen-producing plants especially adapted for military use. Fixed hydrogen plants are of course useful in connection with aeronautic establishments and army centers, but what is especially valuable now is a portable outfit of this kind which can follow the army's movements throughout the country so that the airships can be supplied in the best manner. By the adoption of a hydrogen plant mounted upon railroad cars such as we represent here, it will be seen that the effective work of an airship will be at once increased, owing to the fact that it is constantly kept in good order by the available supply of gas. Wanting this, the airship would often be laid up, or at least subject to more or less delay in carrying out its work.

A hydrogen plant of the present kind not only serves for aeronautic purposes, but the gas can be supplied from either fixed or movable plants for use in different industries developed within the last few years, such as electric welding of plates or bars, and similar work for which a considerable amount of hydrogen is needed at present, also for cutting of plate iron by the hydrogen blowpipe. The hydrogen-producing methods used mainly up to now are purely chemical, electrolytic, or regeneration processes, but all have their disadvantages as compared with the present oil gas method which is used by the inventors. In some cases the first cost or operative expenses are high, and in others the gas needs to be produced on the spot where hydraulic or other cheap electric power can be employed or in the other cases where a water gas plant can be installed to advantage. In such cases the hydrogen needs to be transported in steel bottles under pressure, which is an added cost. Some processes do not give a pure enough hydrogen, one which shall be free from arsenic and chlorine, and it is known that arsenic has caused even mortal accidents in this way. As to chlorine, the gas for use in airships must be free from it, for chlorine attacks the balloon envelope.

According to the new German hydrogen process devised by Rincker and Wolter, the gas can be produced in any suitable place and the plant occupies but a small space, with a very cheap production. At the same time the compact shape of the apparatus makes it very well adapted for mounting upon cars so as to give a portable plant for airships. In fact, it appears that the German army is much interested in the present method and expects to use it for supplying airships of its

numerous fleet. The gas which is produced in this apparatus has but a small percentage of nitrogen and has a specific gravity of 0.087 to 0.092. The operation is based upon the use of crude oil to produce the gas, so that a supply is easy to have. Instead of this, the producer can also be made to work upon benzine, refined oil, benzol and the like. Heating is done by the use of coke, as a general rule, although this can be replaced by charcoal. In the large engraving will be seen the general makeup of the plant mounted upon two railroad cars such as is designed for use in the field in army operations. In this apparatus the first part consists of the gas producer layout which is mounted in complete shape upon the front car, while the second car has the remainder of the plant, including the cooler, scrubber, and other purifying devices. This second part of the apparatus is especially needed for giving pure gas which airships require, as otherwise it need not be as elaborate for use in other industrial processes where less pure gas is needed.

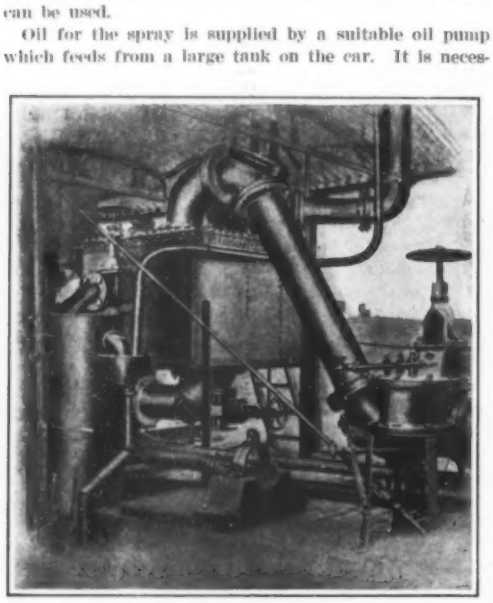
The main apparatus on the front car consists of a pair of gas producers. Each of these has a heavy plate iron casing which is lined with firebrick. To remove slag and ash, there are two doors in the front which are kept closed while the gas is being produced. On the top of the apparatus is a hopper for use in feeding in the coke. At the bottom of the producer are good-sized pipes which bring in the air blast from the blowing chamber. The first of the two producers also has an oil spray device for introducing the oil at the top part. The producer is filled up with coke as is usual in such cases, and hot air is sent in at the bottom coming from a steam turbine driven blast fan, this being worked by the steam from the locomotive. If need be, the blast fan can also be driven by a gasoline motor or crude oil engine of the usual kind, in the case of the portable plant; or with a stationary plant, a gas engine, electric motor or any suitable mechanical drive can be used.

Oil for the spray is supplied by a suitable oil pump which feeds from a large tank on the car. It is necessary to heat this oil before feeding it into the producer, and the steam from the turbine is brought to the tank for this purpose, so that the heating is economically done. At the start of the apparatus, both producers are filled with coke and fired up. By the use of the hot air blast the coke is brought to a white heat, and during this time the coke gases are carried off through the opened top cover and escape into the air through the plate iron chimney. The blast is now stopped and the top cover closed down, whereupon the oil spray is set working, and the oil is transformed into oil gas, this being obliged to pass through the heated coke of the two generators in succession. In this way all the light as well as heavy hydrocarbons are decomposed and the result is a high grade of hydrogen gas containing from 90 to 96 per cent pure hydrogen. Before the producer is actually working to deliver the pure gas to the rest of the apparatus, care is taken to evacuate the gas which was already contained within the producers, and the first part of the newly produced hydrogen is allowed to escape by way of a special valve which is fitted on for this purpose, according to a patented method. During the usual working of the producers, the passage of the gases through the hot mass of coke causes the temperature of the coke to become eventually lowered, and when it cools down below a certain point there will be no more gas generated. When this is the case, the oil feed is stopped and the hot air blast again turned on so as to fire up the coke mass as was done in the first place. Then the oil spray is turned on and the process repeated. Thus the method is an intermittent one, and consists in an alternate operation of the oil spray and hot blast. Firing up the coke by the blast usually takes 2 or 3 minutes during the run, that is, when the coke is still hot, then the gas production lasts for about 20 minutes, and so on.

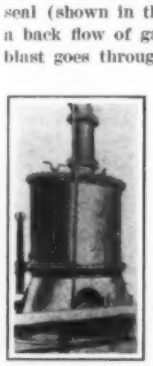
From the second producer the gas goes by good-sized piping into a device which is provided with a water seal (shown in the first engraving) in order to prevent a back flow of gas during the period when the hot air blast goes through the producer. Care is taken in all cases to keep the hydrogen from becoming mixed with air, as is of course quite essential. The gas then passes into the second car by means of coupled piping. On the front end of the car is mounted a well-designed scrubber which is designed with water flow so as to clear the gas of all mechanical impurities such as ash or soot. The scrubber consists of a plate iron case which is filled up with the washing elements of patented makeup, a water flow being introduced at the top, while the gas comes in at the bottom of the scrubber. Means are provided for dividing the gas flow, so that it comes into as good contact as possible with the water.

Next the gas comes into a cleaner which works on a dry process shown in the illustration, and it is designed to remove any sulphur compounds contained in the gas. Here the cells of the cleaner are filled up with a suitable compound which acts as a filter for the gas. For some uses of the hydrogen, the purifying process can stop at this point, as the gas is sufficiently pure for many industrial uses as may be seen by the following analysis: CO_2, 0.0 per cent; O, 0.0; CO, 2.7; CH_4, 0.0; H, 96.0; N, 1.3. The specific gravity of the gas is about 0.1. For such purposes it is not necessary to free the gas from carbon oxide or nitrogen. Next the gas is freed from moisture by sending it through a sulphuric acid dryer pictured in the small engraving and mounted after the other two devices upon the car platform. Last comes a heating furnace for removing the carbon oxide, the furnace being heated by oil gas. Then the gas goes to a cooler, which is built together with the first-mentioned scrubber. Analysis is then as follows: CO_2, 0, $CH_4 = 0.0$; $CO = 0.4$ per cent; $H = 98.4$; $N = 1.2$. Sp. gr. = 0.087 to 0.092.

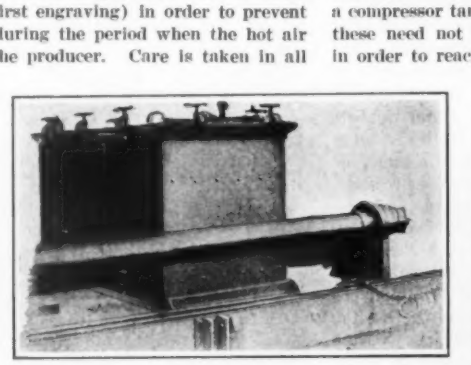
Firing up takes 1 to 2 hours, and the plant can be run for months at a time, needing but two men. The plant follows the airship and either supplies it direct, or where too far off, by a special outfit provided with steel gas bottles. To this end a third car can contain a compressor tank for charging the bottles. In any case these need not be carried to any very great distance in order to reach the airship.



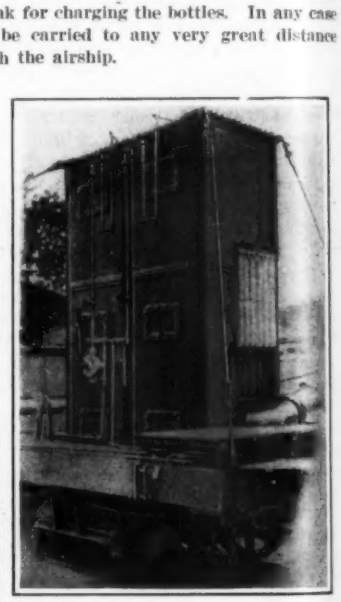
Water seal.



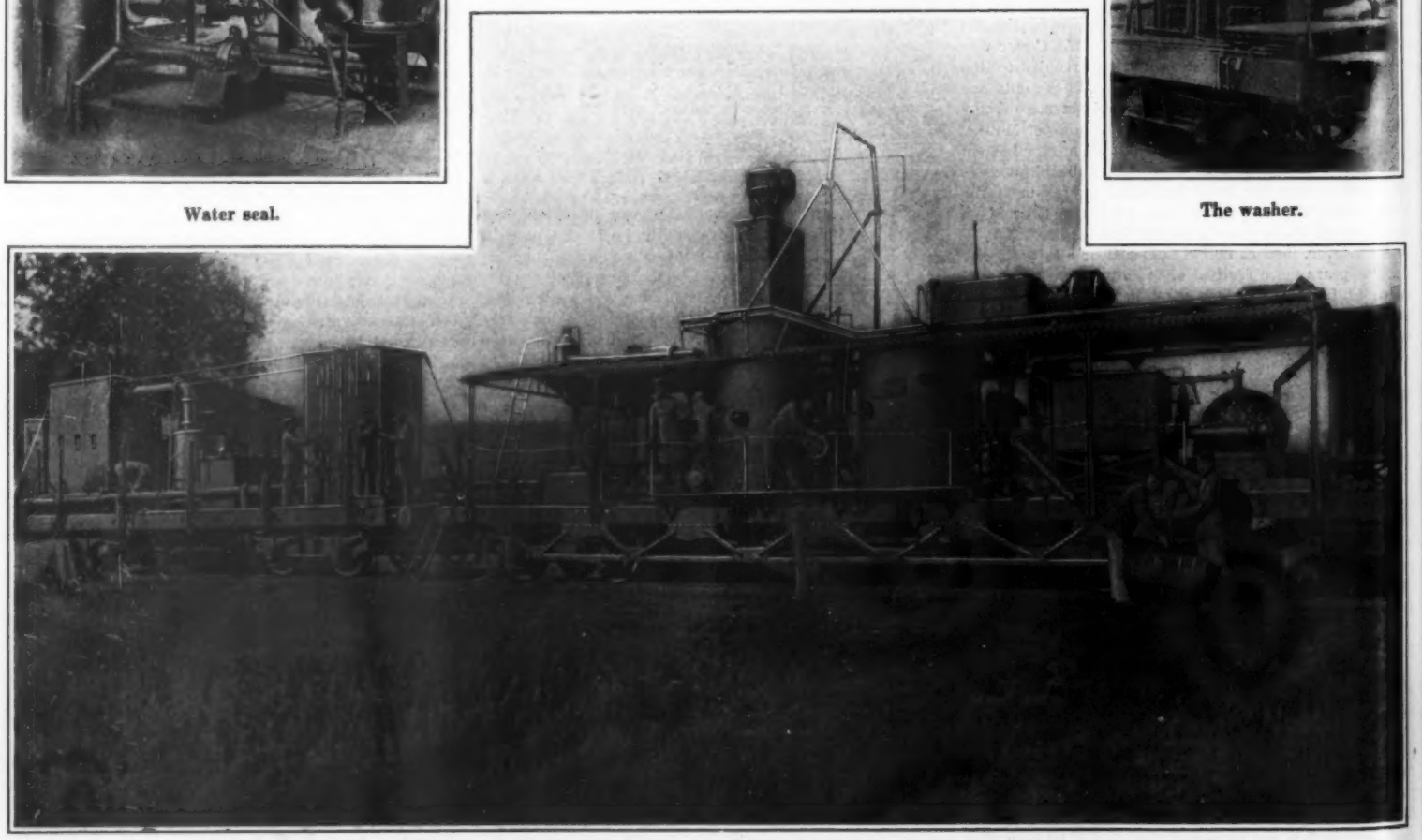
Acid cleaner.



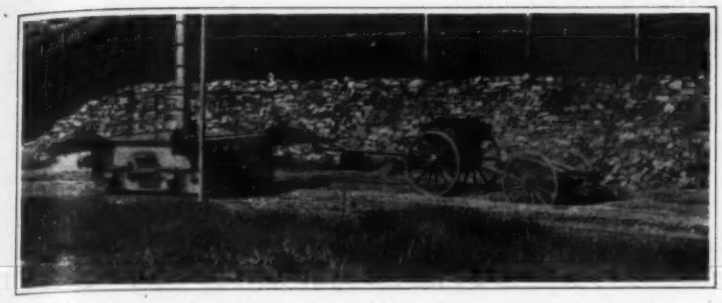
Dry cleaner.



The washer.



Portable hydrogen plant of the German Army Engineers in the field.



Electric motor dragging an ammunition caisson through a hole with steep sides.

Recoil siege cannon upon carriage drawn by horses, clearing a wooden obstacle at the testing ground of Tangerhütte.

How German Artillery is Tested Before It Is Used on the Battlefield

THE Krupp establishment is making use of some very efficient endurance or breakdown tests upon artillery, both for keeping up a check upon the standard types of pieces, and for testing new designs. One of the most novel methods is the use of a circular, electric, testing track, upon which a car is run in order to draw the artillery pieces over the ground at slow or high speeds as may be required.

At the Essen artillery grounds, which lie near the main factories, there is laid out a circular railroad track with a special kind of electric car running upon it, for making the tests upon the artillery. The track has 210 feet mean diameter, which gives it a total length of about 650 feet, being substantially laid on beton and using a single rail on the outer side and a double rail on the inner circle so as to keep the car from running off the track. The railroad track proper is usually reserved for the electric car, while the artillery is run on a circular way, which lies on the inside and also on the outside of the main track, thus allowing two pieces to be drawn along at the same time. The artillery track is slightly banked. The railroad track has a 7-foot 6-inch gage, and, if desired, the artillery can also be run in the space between the rails. In order to vary the tests, the nature of the ground is made different upon various parts of the circular tracks. For instance, some 320 feet of the track or about half the circle is laid with a good stone paving, while the remainder represents country roads in more or less good condition. Upon these different stretches of road there can be placed obstacles of various kinds such as timber lying across the road, ditches or holes and the like. The use of the electric car for drawing the artillery has an advantage from the great number of different running speeds which can be employed, representing what a team of horses would give at a trot or gallop; and much higher speeds can be used when desired.

On the upper floor of the cabin is an inspection room, which serves for engineers or official committees when making certain tests upon the artillery, whence the track can be overlooked. Signals can be sent from the track into the cabin in order to give notice to the operators, and for this use there are placed six signal posts around the track so as to send electric bell signals to the cabin during the maneuvers for changing speed or stopping and the like. Across the car is a bar to which the tongue of the artillery piece can be attached so as to run it on the outer, middle or inner track. The car is started up and the piece is taken around at the different speeds which may be required for any given case, so that it will be seen that the electric track allows any such maneuvers to be made very quickly and avoids loss of time. As regards the obstacles which are put in the way of the artillery piece to give it a severe endurance test, one of our engravings shows a field howitzer taken over a heavy piece of round timber and at a high rate of speed. Seeing that the artillery piece springs up to a considerable height and then falls on the ground, and that its total weight is 2.4 tons, an idea of the good quality of the axles and wheels will be obtained. Another illustration represents an ammunition wagon being drawn at a high rate by the car and passing over a steep ditch dug on the track at this point. It should be stated that the track is well lighted by arc and incandescent lamps. Up to the present time the tests which cover a period of several years amount to as much as 40,000 miles run upon the circular track.

Some very severe tests of another kind are obtained by the use of steam locomotives running on a special stretch of railroad track at the company's artillery grounds at Meppen. At each side of the track is laid out a proving way containing surfaces of varied character or special obstacles. Our engraving shows two artillery pieces attached to a cross-bar, each running on a separate way. Here the road is made up of heavy broken stone. When the locomotive is run at high speed this gives a very severe test, and in some cases the artillery pieces jump bodily from the road to a considerable height. This is the case in our present figure, where the obstacles consist of railroad rails laid crosswise and spaced along the way.

Other endurance tests of artillery are made upon actual roads in the country, using a team of horses as one of our photographs shows. The field piece is here passing over a very high obstacle formed of three logs bound together, and it springs a conspicuous height off the road.

The Synthetic Power of Protoplasm*†

FROM the point of view of the biological chemist the phenomena of life are manifestations of interactions of colloidal and crystalline materials in a peculiarly organized solution; over and above this every form of protoplasm, existent in any organism, is stereochemically ordered in specific relationship to that organism, so that the products of synthesis have an impressed structure and manifest optical activity. It has been suggested by Prof. Armstrong that the protoplasmic complex may be regarded as built up of a series of associated templates which serve as patterns against which change takes place in the various directions necessary for the maintenance of vital processes. This view is based on the well-known relationship between an enzyme and its hydrolyte; the synthetic enzymes, it may be supposed, serve as patterns for the elaboration of complex materials of definite pattern.

In speculating on the origin of organic life from inorganic material Prof. B. Moore has ignored this stereochemical aspect of the question. His use of the well-known synthesis of formaldehyde from carbon dioxide and water in presence of an inorganic catalyst—in his case a colloid—can lead only to optically inactive material, and there is no justification even for the mention of the term life until evidence of directed synthesis is adduced.

The stereochemical hypothesis enunciated has been advocated by Prof. Reichert of Pennsylvania in his researches on hæmoglobin, in which he showed that this substance is modified in specific relationship to genus and species. He now extends the hypothesis to the study of starch, expecting that the peculiarities of the protoplasm in different species of plants will occasion the formation of different types of starch. The variations in the starch granule with origin are, of course, well known, and they are of industrial importance. They are now shown to be absolutely diagnostic in relation to the plant and to constitute a strictly scientific basis for the classification of plants. In addition to recording the microscopic characters of the starches an attempt has been made on a large scale to characterize them chemically, and although these tests are admittedly crude and leave much to be desired, they do mark a great advance in the treatment of the subject.

It may be regarded as established that starches of different origin vary both visibly and in chemical properties; moreover, plants of closely allied species contain starches with similar properties, and it is logical that such variations must be attributed to the differences of protoplasmic influence under which the starch granules are formed. It must not be overlooked, however, that starch granules are made up of three kinds of substances, namely, the true starch degradable to maltose, which forms the bulk of the granule, amylocellulose or amylopectin, and a small proportion of carbohydrate, possibly crystalline, soluble in cold water. It is probable that these are present in different proportions in the various starches, and so give rise to such differences as Reichert has observed.

Some valuable observations on the characters of hard and tender barleys, published by H. C. A. Vine in the *Journal* of the Institute of Brewing, may be mentioned in this connection. A barley corn may contain starch granules of all sizes, the variation being due to the conditions under which it develops. Malnutrition of barley leads to a high ratio of small starch granules which are more resistant to enzyme action, to moisture and to heat than the normal mature granules. Those granules which have the more favorable position in the inclosing cell are able to appropriate a large proportion of the nutriment supplied by the protoplasm and so become normal large starch granules, each consisting of many layers containing much granulose, tender and readily acted upon.

Similar observations were made by the writer some years back when it was pointed out that there is considerable variation in the proportion of large to small granules in wheat starch. Those types of flour which are the best for certain purposes contain the greatest proportion of large granules, the property being quite characteristic.

Hence it would seem that, over and above species variation, differences due to environment and nurture may appear in the starches, and it is possible that the further study of such a substance as starch may provide material for the solution of many vexed problems.

In addition to the detailed account of the tests applied to each starch, which are recorded also in the form of a curve which is shown to be characteristic for each individual, Prof. Reichert includes in his book a beautiful series of photomicrographs taken in ordinary and polarized light. These enhance very materially the value of the work, although they must have increased greatly the cost of publication. The author has further been at pains to summarize at some length previous work on starch, both on the chemical and on the botanical side. His account is a valuable one if only as showing how much uncertainty exists at present in the knowledge of starch and its transformations.

* Reproduced from *Nature*.

† "The Differentiation and Specificity of Starches in Relation to Genera, Species, etc." Stereochemistry Applied to Protoplasmic Processes and Products, and as a Strictly Scientific Basis for the Classification of Plants and Animals. By Prof. E. T. Reichert. In two parts. Pp. xvii + 900 + 102 plates. (Washington, D. C.: Carnegie Institution of Washington, 1913.)

A test over specially prepared roadway composed of large stones, cement, and boulders.

Two field guns and their fore-carriages drawn by a steam locomotive over obstacles consisting of railway rails.

The Flying Machine from an Engineering Standpoint—V*

A Review of Recent Progress

By Frederick William Lanchester, M. Inst., C.E.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2017, Page 144, August 29, 1914

12. *Landing Gear.*—S. The question of alighting mechanism detail next claims our attention; this is necessarily of two distinct types, depending upon whether the machine is designed for land or for marine usage. Taking first the land or military type of machine, the essential features comprise, ordinarily, a pair of pneumatic-shod wheels (in some cases, two pairs) arranged on a common axis somewhat forward of the center of gravity of the machine, and supplied with a rudimentary elastic suspension of some form, in addition to runners or skids to take the "bump" in emergency, and the provision of some kind of temporary tail support, consisting either of a caster-pivoted wheel, or (as more generally the case) of a simple spring-controlled skid. It was at one time believed to be essential that the alighting wheels should be all caster-pivoted or orientable, the intention being to take care the liability of the landing chassis to injury it is clearly desirable that its structure should be complete within itself, yet this is very difficult of achievement in actual design; more often than not there are members in common to the landing chassis and the aerofoil structure or the fuselage. This must be considered a weak point in any design, since it involves the risk that some essential flight organ may on landing be strained or otherwise injured, or at least stressed beyond the limit for which it had been designed.

In spite of all that has been done up to the present, the landing chassis is only able to take a very moderate "bump" with safety, a 1-foot free fall onto a hard surface is as much as can be deemed safe in the best of existing machines; a free fall of 4 feet or 5 feet would lead to almost certain failure. This requires that, in landing, a machine should never, under any circumcentral boat, as already to be seen in the Curtiss and Sopwith machines (Fig. 34); here auxiliary floats or bob-floats are fitted to the extremities of the aerofoil to give stability to the machine when resting on the water, and to avoid damage to the aerofoil when getting under way or when alighting.

The main floats, whether single or double, require to be constructed to rise in the water on the same principle as the so-called hydroplanes or skimmer craft, being designed with the usual stepped bottom; a single step is found to give the best results.

The design of floats or hull for a marine machine must be regarded as still in an early stage of development, and much will depend in the future on the general evolution of the machine as to what form of float gear will ultimately be found most appropriate. The author is of opinion that, as a development of the single-

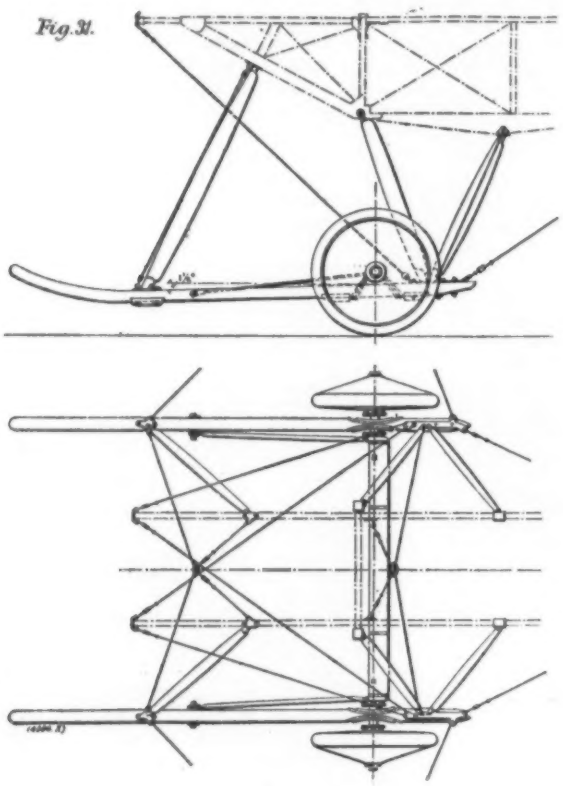


Fig.31.

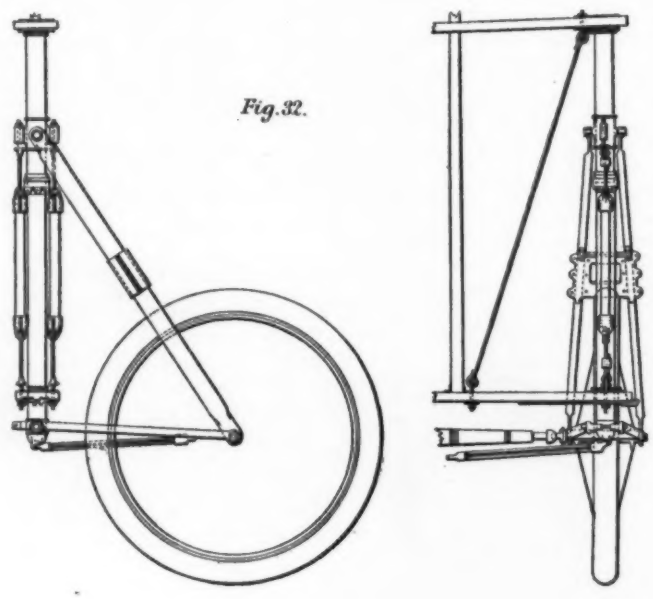


Fig.32.

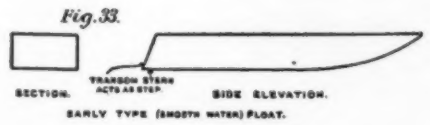


Fig.33.
EARLY TYPE (SMOOTH WATER) FLOAT.

of the relative motion of the ground when alighting across the wind;[a] experience appears to show that with reasonably careful handling this provision is unnecessary. Two types of suspension are illustrated in Figs. 31 (Royal Aircraft Factory) and 32 (Blériot); it will be noted that in both cases the medium employed to absorb the shock is rubber; this is preferable to steel (as universally employed on road vehicles) for two reasons: first, the energy good vulcanized rubber will absorb is far greater than is the case for steel; it runs to some 500 pounds to 1,000 pounds per pound (some 10 or 20 foot-pounds is all that may be allowed for steel); and secondly, the signs of fatigue in rubber are evident to the most casual observer, and the rubbers are cheap and easy of replacement. The alighting wheels with their associated parts are mounted on a structure commonly known as the landing-chassis, whose function is to raise the machine proper a sufficient height above the ground to provide clearance for the propeller, aerofoil, etc.; unless careful design and workmanship are put into the landing chassis its "spidery" proportions necessary to give clearance may, on the one hand, constitute a source of weakness, or, on the other, give rise to excessive resistance. Owing to stances, be allowed to take the ground with a greater vertical velocity component than 8 feet per second. Assuming a gliding angle of 1/7, this means that a machine, flying at 38 miles per hour (56 feet per second or foot-second) could be allowed to take the ground (presuming the latter horizontal), without intervention of the pilot; but for any higher velocity of flight its course must be eased or flattened. In actual practice it is, of course, part of the art of flying to avoid all shock when alighting, no pilot would think of taking the ground without at least making his best effort to flatten his angle of descent. There is probably a future for some form of hydraulic pneumatic device; already several attempts have been made in that direction.

Passing now to the marine type, we find in the earlier examples a landing chassis of the ordinary pattern fitted with a pair of floats in place of wheels and skid, and a temporary tail support in the form of a third float arranged aft under the tail member. In the earlier machines these floats were little more than boxes of rectangular section, Fig. 33; recently there has been a tendency to give to the floats a more boat-like form,[a] surfaces of single or double curvature being adopted in place of flat, and so the liability to being stove in has been reduced to a minimum. The double float support has proved itself suited to comparatively smooth water, but a strong feeling exists at the present time that for machines intended to serve on the high seas that construction will be abandoned in favor of the single boat type at present existing, it would appear to be desirable to bring the motor or motors, and other heavy parts as far as possible, down into the hull, and design the boat as a thoroughly seaworthy craft with proper metacentric height and fitted with its own (marine) screw-propeller, so that it is capable of being navigated independently of its flight organs (Fig. 35). In such a design it would evidently be necessary to drive the propellers through a belt, chain, or gear of some kind, and mechanism would be provided by which the pilot could jettison the superstructure in emergency. Such a machine would be essentially one of considerable size, and would probably be fitted with two, three, or even more engines, with a total of over 500 horse-power. The weight of such a machine would require to be some 3 or 4 tons, and would be capable of making port under its own power if the flight organs were abandoned.

13. *Acentric Types of Machine.*—The type of machine here suggested would be liable to certain objections on the ground that the line of the propeller thrust is acentric, being situated considerably above the center of gravity, and probably also above the center of resistance of the machine; conversely, the center of gravity would be considerably below the center of resistance; these are objections which have been raised with regard to some existing machines. It is undoubtedly desirable, where other considerations permit, to bring the center of propulsion, center of resistance, and center of gravity to approximately the same level. There is no fundamental difficulty in flying a machine in which this condition is not complied with, since any pitching moment that results from the want of concentricity can

* The James Forrest lecture, delivered before the Institution of Civil Engineers on May 5th. Compare also the same author's paper on "Catastrophic Instability in Aeroplanes," SCIENTIFIC AMERICAN SUPPLEMENT, February 14th, 1914, page 98.

[a] Messrs. Voisin Brothers, in the days of their pioneer work, attached great importance to this point. They attributed the early success of Farman (on his Voisin machine) largely to the fact that this feature was embodied in his machine.

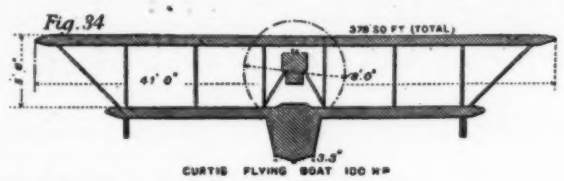
[a] An instructive series of trials have been made in the Yarrow Tank at the National Physical Laboratory. Advisory Committee Report, 1912–13, Memorandum No. 70 (Baker and Millar).

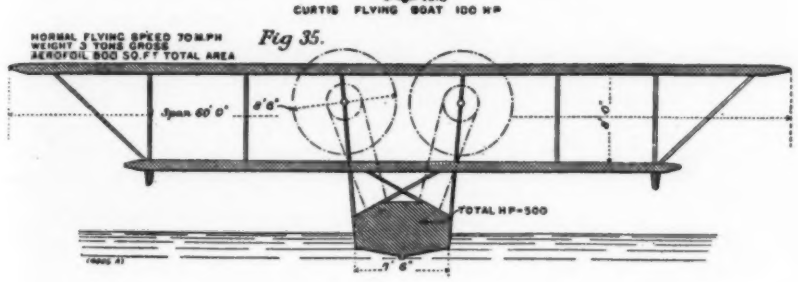
be corrected by suitably arranging the center of gravity. Serious difficulty, however, is liable to arise in the event of a sudden change in the mode of flight, such as is brought about when the engine is cut out. Under these conditions, the machine being propelled in gliding flight by a component of gravity instead of by the propeller thrust, a change of pitching moment takes place equivalent to the total resistance of the machine, multiplied by the vertical distance between the line of propulsion and the center of gravity. In a machine of the type above suggested, such a change of moment would be the equivalent of a movement of the center of gravity through a distance of nearly 2 feet, a change which we must regard as of dangerous magnitude.

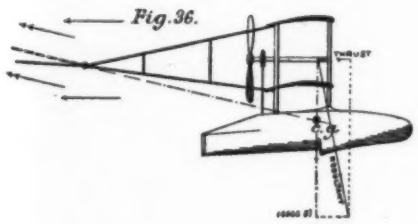
The position is that shown diagrammatically in Fig. 36, in which it will be seen that the resultant of gravity and the propeller thrust passes some considerable distance in front of the center of gravity, whereas in gliding flight the resultant of the lifting and propelling forces is the force of gravity, and so passes through the center of gravity.

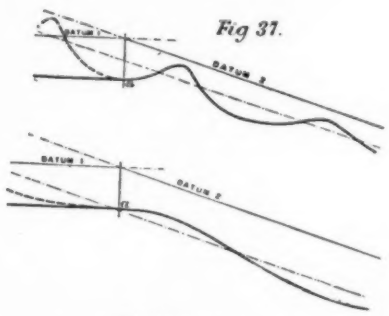
It has been suggested that by arranging the tailplane (and elevator) in the wake, in the propeller slipstream in fact, and giving it an upward rake, in other words, by employing a negatively loaded tail, the tail may be made to supply a countervailing pitching moment when the propeller is at work; thus, while the direct effect of the propeller is to tend to lift the tail and depress the nose of the machine, the indirect effect brought about by the action of the slip-stream on the upturned tail will be the inverse. It might be possible in this way to correct a small want of concentricity of the propeller axis, but such a method would scarcely be applicable to the case in point. In order that the method in question should be effective, the slip-stream must be discharged radially from the center of gravity of the machine; that is to say, the general body of air discharged in the slip-stream must be so deflected that its moment of momentum about the center of gravity is zero. Roughly speaking, this means that the tail, as shown dotted in Fig. 36, must be set at such an angle as, if produced, would pass through the center of gravity of the machine; the double-headed arrows show the slip-stream diverted as theory requires. The method is evidently impracticable; not only is the tail angle as necessitated altogether excessive, but also the whole story has not been told—the tail would require to be "feathered" immediately the propeller ceases its function, otherwise it would continue to supply a moment of some magnitude when no longer required.

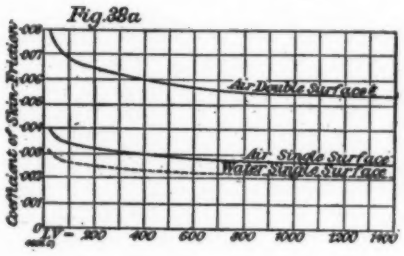
It is of interest to examine in greater detail the behavior of a machine such as we are considering under flight conditions. It is clear that if at any instant the engine is switched off, two things happen: First, as in a machine of the concentric type, the supply of energy being withdrawn, the datum of the phugoid chart takes a downward trend; its down slope is that of the gliding angle, Fig. 37, datum 2. Secondly, since the withdrawal of the thrust, reaction is in effect equivalent to a movement backward of the center of gravity, the angle of attack of the aerofoil is increased and the natural velocity of the machine is reduced, and H_n is diminished to a corresponding degree. The conditions are thus represented by the upper diagram in Fig. 37; the reduction of H_n being calculated, we consult the phugoid chart and select the curve to correspond; as shown, this has been taken as curve *G* from Fig. 2. In the lower diagram, Fig. 37, a similar construction has been shown for a machine nearly concentric as to its thrust; the resulting phugoid here corresponds to that labeled *C* in Fig. 2. The case of least disturbance is that in which the original flight path picks up the new flight path at its point of inflection; that is the case if the propeller axis is slightly below the center of gravity, since then on cutting out the engine the value of H_n is slightly increased; this is as actually represented on the lower diagram.

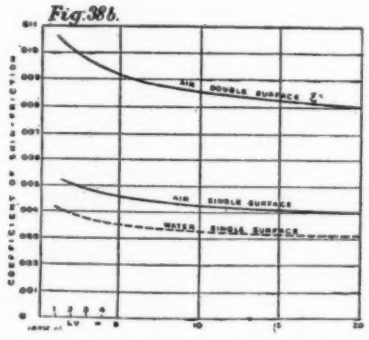


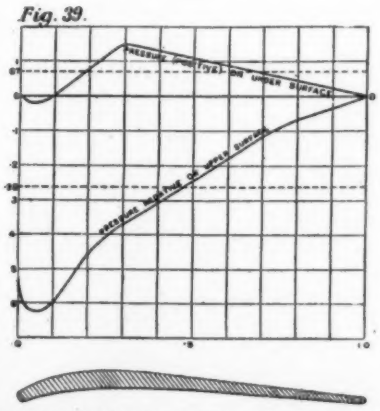


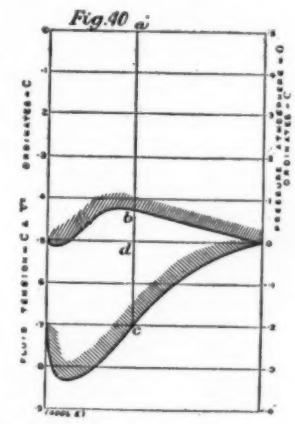


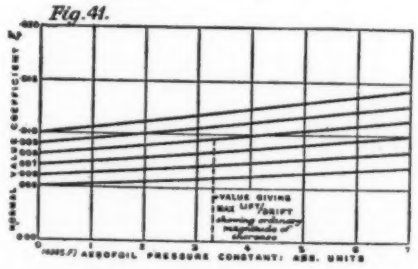












At present there are difficulties of the character and extent outlined standing in the way of development in the direction indicated; they are difficulties that will without doubt be eventually overcome.

14. *Stability and Control.*—In the present lecture all questions of stability in the ordinary sense have been taken for granted. The problems of longitudinal stability, lateral and directional stability, and spiral or rotative stability, though of vital import to the aeronautical engineer, are primarily matters for the physicist and mathematician; the engineer can well afford to leave questions of this character in the hands of the specialist.

There is perhaps less excuse for the absence of all mention of controlling mechanism; a great deal might be added on that subject, without going beyond the scope of the title. However, since the question of control is closely wrapped up with considerations relating to stability, and since it is necessary to draw a line at some point, the omission is one of expediency rather than logic.

The question of stability is not, as is frequently supposed, one that is in any sense obscure; in fact, from the scientific point of view, the present position is at least satisfactory; it can be said without exaggeration that we have a great deal more knowledge on the subject than we are at present able to utilize.

There is very little of importance, specifically relating to the stability of the flying machine, that has been written, either before or since, that will not be found either in the work of Dr. Bryan[a] or in "Aerial Flight."[b] A few notes have appeared in the various reports of the Advisory Committee for Aeronautics, but not very much; two short notes of a somewhat trivial character appear in the report of 1909-10, in addition to an excellent abstract of Soreau's "Etat actuel et avenir de l'Aviation."[c] In the reports for 1910-11 and 1911-12 there is nothing; in the report for 1912-13 there are two or three interesting communications, mainly due to the staff of the National Physical Laboratory, notably memoranda Nos. 77, 78, and 79. No. 77 (L. Bairstow, Melville Jones, and A. W. H. Thompson), is, in the main, an examination and extension of existing theory following the methods initiated by Dr. Bryan; No. 78 (L. Bairstow and L. A. MacLachlan), mainly relating to the determination of the various coefficients required for the application of Dr. Bryan's method of treatment. No. 79 (L. Bairstow), dealing with the more detailed application of the same method. These communications are conspicuous by the fact that their authors appear to be really *au courant* with the previous literature of the subject.

The work that has been done on the Continent on the subject of stability does not in sum amount to much; moreover, it frequently appears to suggest complete ignorance of what has been done in this country; in this particular matter it would seem that the Continent has become insular and our island cosmopolitan. For example, we find the work of Georges de Bathezat,[d] described by Mr. Painleve as "the first to give an exact and complete discussion of the stability of the aero-

[a] G. H. Bryan, "Stability in Aviation," Macmillan & Co., 1911.
[b] "Aerodonetics," vol. ii. Constable & Co., 1908.
[c] Mémoires, Société des Ingenieurs Civils de France.
[d] "Étude de la Stabilité de Aeroplane." Dunod, Paris, 1911.

plane"; and when we examine the work so described, we find the subject not more than half dealt with, and at that in so ineffective a manner that scarcely one of the conclusions can be regarded seriously. R. Knoller[50] and Reiszner,[51] though interesting, do not materially advance the subject. H. Soreau deals with the subject of longitudinal stability under two distinct headings—equilibrium and stability; so far as the former is concerned, his conclusions as formulated will be found in their entirety published by me in 1897, with the *rationale* clearly set forth.[52] Soreau, however, scarcely carries the matter as far as in my previous publication. Incidentally, Soreau gives two propositions, i. e., minimum tractive force and minimum horsepower, which, except for differences of notation, appear to be identical with two propositions previously given by me in "Aerodynamics," 1907, sec. 164. When we come to the question of stability, it will suffice to state here that his conclusions on the subject of longitudinal stability are gravely at fault; briefly, Soreau states that the moment of inertia must not be too small for fear of oscillations becoming too rapid, whereas the only oscillation of importance—my "phugoid oscillation"—is virtually independent for its period on the value of the moment of inertia. On the questions of lateral stability and directional stability, Soreau's views (as pointed out by Bryan) are entirely at fault; the whole question of asymmetric or rotative stability is lost sight of, and the fact that in directional stability the center of gravity cannot be treated as a static pivot[53] is ignored.

The work of Capt. G. A. Crocco[54] is of interest. In the main he follows established mathematical lines of treatment. I have made no attempt to follow his work in detail. Capt. Crocco's conclusions on the whole appear to be far sounder than those of most Continental writers; his work is evidently worth careful study.

The above may be taken as a brief summary of the existing literature of the subject. Excellent abstracts of the work of the foreign authors cited will be found in the appendices to the various reports of the Advisory Committee; excepting in the case of the French writers, which have been consulted in the original, I have relied on the abstracts in question for the summary here given.

APPENDIX I.

The subject of skin friction where air is concerned has been one of considerable controversy. The quantities to be measured are so small, and the apparatus employed until recent years has been so insensitive, that until the work of Zahm in 1904 very little was known on the subject. Langley, in his "Experiments in Aerodynamics," 1891, asserted skin friction to be a negligible factor in its relation to flight. Dines about the same date expressed the same view. In my "Aerial Flight," vol. i., which appeared in 1907 (not at that time aware of the work that had been done by Zahm), I published some determinations of skin friction, and attacked Langley's views, pointing out that skin friction is one of the controlling factors in the economics of flight. I also introduced the practice of expressing skin friction as a coefficient representing the resistance of a thin lamina in tangential motion in terms of its resistance at 90 degrees; the coefficient so expressed is the double surface coefficient, and in my work is represented by the symbol ξ. In the greater part of my experimental work, planes or laminæ of mica were employed of but a few square inches area; the largest area used by him in any of his determinations was approximately ½-square foot. Now it is well established that the coefficient of skin friction in a plane of small area is sensibly greater than in one of large area, consequently my values were on the whole considerably higher than those of experimenters working to a larger scale; however, the following passage may be cited as the summary of experiments made with planes of about ½-square foot area, and of smooth surface: "It is, therefore, to be concluded that for a well-varnished surface or for polished metal, under the conditions of experiment, the effective value of ξ is approximately 0.009 with a probable error of less than 10 per cent, plus or minus."[55] According to the best estimate that can be made to-day the actual value of the double surface coefficient under the conditions of the experiment in question should be 0.0081, showing an error of precisely the 10 per cent which I allowed myself.

In a communication to the Advisory Committee for Aeronautics (Memorandum No. 15, June, 1909), I pointed out that my own results and those of Zahm for air, and the results obtained many years ago by W. Froude for water, are in substantial agreement—in fact, in very close agreement—provided that they are put in their proper perspective, with due consideration to the laws of dynamic similarity.[56] The conclusion given in the memorandum under discussion is expressed in graphic form in Figs. 38*a* and 38*b*, in which the abscissæ represent the quantity $L\,V$ (the product of the linear dimension[57] in feet by the velocity in feet per second), and in which ordinates represent the coefficient of skin friction. Three curves are shown; the upper curve is the double surface coefficient for air, for which I employ the symbol ξ, the lower curve (solid line) is the single surface coefficient (half the value of the former), the dotted curve is the coefficient for water. In Fig. 37, $L\,V$ values may be read from 20 to 1,400. In Fig. 38 is given a graph for lower values.

It is a point not without interest that, for geometrically similar aerofoils, the weight sustained varies as $(L\,V)^2$, consequently for any given value of $L\,V$ the weight is constant. In other words, as already shown, for least resistance $P = C\,\rho\,V^2$, where C is a constant whose value is round about 0.32, or if $k\,l^2$ represents the area, and W = weight,

$$W = 0.32\,k\,\rho\,(L\,V)^2.$$

Therefore, assuming good design (max. lift/drift), and some definite value of aspect ratio (to fix the value of the constant k), the coefficient of skin friction is determined by the weight of the machine, and is the same whatever the designed velocity may be.

Skin friction has a habit of playing an elusive part in actual resistance phenomena, and the subject in practice is full of pitfalls. In the case of a plane moving edgewise, it may frequently happen that skin-frictional resistance will virtually disappear, the leading edge of a plane, such as used by the late Prof. Langley, will by its bluffness set in motion a certain quantity of air, and this moving air subsequently washing the surfaces of the plane will reduce the skin-frictional resistance to something immeasurably small; as pointed out by me in discussing Langley's work, this was one of the causes that led him into error.

Another case where the coefficient of skin friction may be abnormally low is that of the inclined plane at a small angle of incidence; in "Aerial Flight," vol. i., the matter is dealt with on page 264, article 182; it is pointed out that as a deduction from gliding experiments made with the ballasted plane, and calculations based on them, the coefficient of skin friction is in effect less than ordinarily the case, and the explanation is offered that the upper surface of the plane being to a certain degree a "dead-water region," the coefficient may in this case be only that of the single surface. This conclusion has received striking confirmation in connection with some experimental work recently carried out at the National Physical Laboratory.

I consider it probable that in the case of the pterygoid aerofoil—that is to say, the aerofoil of arched section, such as shown at the foot of Fig. 39—the skin friction may in effect be abnormally high, owing to the augmented velocity with which the air flows over the upper surface. This, speaking generally, is not altogether compensated by the lower velocity on the under side. The velocity of the air in the vicinity of the aerofoil can be deduced approximately from the ordinary laws of fluid motion from the local pressure. Now pressure curves have been made of several different sections of aerofoil by the National Physical Laboratory; the curve shown in Fig. 39 may be taken as roughly typical of the pressure graph for mid-section of any well-shaped aerofoil at or about its angle of least resistance. The ordinates downward from the zero datum line being negative pressures on the upper surface of the foil, and the ordinates measured upward from the said datum line being the positive pressures on the under surface, in both cases measured above and below atmosphere. Plotting the same curve in Fig. 40, and taking a datum line corresponding to zero motion, ordinates will represent fluid tension (negative pressure), and the velocity at every point is represented by the square root of its ordinate; hence the skin friction will vary as the ordinate itself, and, referring to Fig. 40, the effective coefficient of skin friction will be greater than normal in the relation of the mean of the ordinates $a\,b$, $a\,c$ to the ordinate $a\,d$. Referring again to Fig. 39, it may be observed that the mean pressure increase on the under face is approximately one fourth of the mean pressure decrease on the upper face; taking this proportion as a basis, I give, in Fig. 41, graphs of the augmentation of the skin friction as a function of the aerofoil-pressure constant; the normal coefficient proper to the $L\,V$ value in question being read on the ordinate corresponding to pressure constant = zero, on the left hand of the figure. In the case, for example, of the normal value of the coefficient being 0.008, it will be seen that for a pressure constant = 0.32 the augmented coefficient will be nearly 0.01.

We thus begin to obtain values approaching those that I have found to apply in connection with the theory of least resistance. If, in addition to the above, we allow an addition to represent form resistance, as has been found by Prandtl in the case of the ichthyoid body, and which is due to the degeneration of the stream-line system consequent on the appearance of the frictional wake, we might expect the effective direct resistance of the aerofoil expressed in terms of skin friction equivalent to a coefficient of 0.0175, which is in full and complete agreement with experience. The assumption here is that the proportion of the added form resistance bears the same ratio to the true skin friction, approximately 3:4; as commonly found in the case of the ichthyoid body.

[50] "Uber Langstabilität der Drachenflugzeuge," 1911.

[51] "Einige Bemerkungen zur Seitenstabilität der Drachenflieger," 1912.

[52] Patent Specification 3608, 1897, or compare also "Aerial Flight," vol. ii, page 353.

[53] Compare "Aerial Flight," vol. ii, sections 95 to 100; also Bryan, "Stability in Aviation," Chapter vii.

[54] "Sulla stabilita laterali degli aeroplani," also "Perfezionamenti nella stabilita longitudinale degli aeroplani," "Rendiconti delle Esperienze e degli Studi eseguiti nella Stabilimento di Costruzioni Aeronautiche del Genio Anno II."

[55] "Aerial Flight," vol. i, page 389.

[56] Compare the memorandum cited, also addendum to same by Lord Rayleigh.

[57] Ordinarily the linear dimension, represented in the laws of dynamic similarity by L, presupposes geometrical similarity—i. e., geometrical form as an invariable. In the present usage, owing to the thinness of the layer of air effected, L may be taken as the linear dimension of the plane in the direction of motion.

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